A COMPLEAT

SYSTEM OF ASTRONOMY.

In Two Volumes.

CONTAINING,
The Description and Use of the Sector, the Laws of *Spheric Geometry*; the *Projection of the Sphere* Orthographically and Stereographically upon the Planes of the Meridian, Ecliptic and Horizon; the *Doctrine of the Sphere*; and the Eclipses of the Sun and Moon for Thirty nine Years.

Together with

All the PRECEPTS of Calculation.

ALSO

New Tables of the Motions of the Planets, Fix'd Stars, and the First Satellite of *Jupiter*'s Declinations to every Degree and Minute of the Ecliptic, to six Degrees of N. and S. Latitude; of Right and Oblique Ascensions, and Logistical Logarithms.

To the whole are Prefix'd,

ASTRONOMICAL DEFINITIONS,

For the Benefit of Young Students.

The Second Edition, with Additions.

By Charles Leadbetter, Teacher of the Mathematics.

LONDON:
Printed for J. Wilcox, at *Virgil's Head*, over against the *New Church* in the *Strand*.

MDCCXLII

TO ALL

LOVERS

OF

Mathematical Learning;

This COMPLEAT

SYSTEM

OF

ASTRONOMY

Is, with all Humility, Dedicated

BY

Their moſt Faithful and Obedient Servant,

Charles Leadbetter.

THE

PREFACE.

ASTRONOMY is a SCIENCE, which teaches the Method of Examining and Calculating the Motions, Magnitudes, Distances, Conjunctions, Eclipses, Apogeons, &c. of the Heavenly Bodies, by the nbers, Geometry, Telescopes, Quadrants, and Micrometers.

BY this we may walk through the Air and *Æther*, and converse familiarly with the most wonderful Parts of the Creation. *Atlas*, the *Lybian*, and King of *Mauritania*, forsook the Society of Men, and retir'd to the highest Mountain in *Africa* (which therefore bore his Name) that he might contemplate upon the Motions of the Fix'd and Erratic Stars; and is for that Reason said to bear

up the Heavens with his Shoulders. He was the Inventer of the Spheres 1590 Years before Christ.

THE Poets have feign'd the Moon to be in love with *Endymion*, becauſe he ſpent his Time upon Rocks and Mountains (chiefly on Mount *Latmos*) in ſtudying the Nature of the Moon and Stars, 1445 Years before Christ.

WE are not at all ſurprized to find ſo many great Men affect this Study (the Names of ſome of whom that have arrived to a very great Proficiency, you may ſee in the Preface to my *Syſtem of the Planets demonſtrated*,) and endeavour the Knowledge of ſuch things as raiſe the greateſt Admiration in all who are ignorant of it.

To ſee a regular Succeſſion of Day and Night, a conſtant Return of Seaſons, and ſuch an harmonious Diſpoſition and Order of Nature, muſt neceſſarily be a Noble Contemplation, and agreeable not only to the Nature of Man, but alſo to the Poſture of his Body, which is Errect; when other Creatures (wanting that Muſcle) are made to look downward upon the Earth.

THERE have been great Contentions among the Learned of different Nations about the Orgin of this Study, every one claiming an Intereſt in it; as, the *Babylonians*, *Egyptians*, *Grecians*, *Scythians*, &c. But be that as it will, we now enjoy it in a very clear Light, to the immortal Honour of thoſe two Great Geometricians, the late Sir *Iſacc Newton*,

and

and Dr *Edmund Halley*, our present Aſtronomer-Royal.

UPON this Science depends Navigation, Geography and Dialling; without which 'tis impoſſible they ſhould be maintain'd: For, firſt, the Mariner cannot conduct a Ship through the unbeaten Paths of the Ocean, without the help of it; but being well skill'd in Aſtronomy, he may, by the Knowledge of Eclipſes, and Immerſions and Emerſions, of *Jupiter*'s Satellites, and the Times of the Tranſits of the Moon by the fixed Stars and Planets, determine the true Difference of Meridian between *London*, and the Meridian where the Ship then is; which reduced into Degrees and Minutes of the Equator, is the true Longitude found at Sea.

SECONDLY, The Geographer is aſſiſted hereby, in laying down the Cities, Towns and Countries in their true Longitude and Latitude.

LASTLY, It is by the help of this Science, that the Dialiſt is inform'd how to trace out the true Hour of the Day (in any part of the World) by the Shadow of a *Gnomon* plac'd on a Plane, tho' never ſo irregular. See my *Mechanic Dialling*.

WE read of many Perſons, who in this Study have trod ſo near upon the Heels of Nature her ſelf, and have div'd into things ſo far above the Apprehenſions of the Vulgar, that they have been believ'd to be *Necromancers*, *Magicians*, &c. and what they have done, judg'd to be unlawful, and perform'd by Conjuration and Witchcraft, altho'

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the Miſtake lay in the Peoples Ignorance, and not in the others Studies.

To undertake a Work of this Nature, is to launch into the Ocean of Critics. However, ſince no abler Pen would undertake this *Herculean* Task, I have ventur'd to beſtow this my Twenty Years Study and Labour among my Country-men, wiſhing they may reap as much Profit, as I have had Pleaſure in Compiling this Work.

But whoſoever they be that read Authors, and do not by their own Senſe abſtract true Repreſentations of the things themſelves comprehended in thoſe Authors Expreſſions, they do not repreſent true, but deceitful Idea's and Phantaſms, by which means they form certain Shadows and Chimæras, and all their Theory and Contemplation (which they count Science) ſhew nothing but Weakneſs.

In the following Work I have added nothing ſuperfluous, nor omitted any thing that would be of uſe to the young Aſtronomer: For in the firſt Place, I have given you all the Terms of Art uſed in Aſtronomy; by which the young *Tyro* is taught to ſpeak properly, without any other Guide or Tutor whatever.

The Body of the Work I have divided into Five Sections: The firſt contains the *Deſcription* and *Uſe* of the *Sector*; the ſecond contains *Spheric Geometry*; in the third you have the *Projection of the Sphere* Orthographically and Stereographically,

on

on the Planes of the Meridian, Ecliptic and Horizon: In the fourth Section you have the *Doctrine of the Sphere*, according to the apparent Motion of the Sun; wherein I have given the Problems in the ſame Order in which they ought to be learn'd; with an *Appendix* of ſuch Tables as I thought neceſſary for compleating this Work. The fifth and laſt Section contains *Aſtronomical Precepts*, which ſhew the Uſe of the Tables in an eaſy and practical Method, being all that is required to be known by them.

IN the ſecond Volume you have New and Correct Tables of all the Planets and fixed Stars, which are grounded upon Sir *Iſacc Newton*'s *Radixes*, and the Obſervations of Mr *Flamſteed*: For by comparing as many Obſervations of Eclipſes as I could procure, I found that all our *Aſtronomical Tables* were faulty in the times of thoſe Eclipſes, giving the times in the Aſcending parts of their Orbs too ſoon, and in the Deſcending too late; which put me upon endeavouring to rectify that Error.

I ALSO obſerving (as Mr *Flamſteed* and Dr *Halley* had done before me) that *Saturn* mov'd too faſt by the *Tables*, *Jupiter* too ſlow, and *Mars* too ſlow in *Aphelion*, and too faſt in *Perihelion*; theſe Irregularities you will find rectify'd in the following Tables, and brought to agree with the Obſervations of this preſent Age.

I HAVE alſo rectify'd the Præceſſion of the Æquinox to its true Place, and near 800 of the fixed Stars, by my Aſtronomical Quadrant; the Limb

Limb of which is divided into Minutes of a Degree. The Method of making Obſervations I have ſhewn in *Problems* 41, 42, *&c.* of the *Doctrine of the Sphere.*

In the 119th Page of my *Syſtem of the Planets Demonſtrated,* I have ſhewn you, how the Declinations of the fixed Stars increaſe and decreaſe; and that, by reaſon they move upon the Poles of the Ecliptic, they are found at different Diſtances from the *Vertex* of any Place: As, for Inſtance, that Star in the *Tail* of the *Little Bear*, which we call the *Polar Star*, was not the Polar Star at the Creation of the World, neither will it be the Polar Star 13337 Years hence; for it will then be 8° 56′ 49″ to the South of the *Vertex* of *London.* This may ſeem to thoſe who are unacquainted with this Study, to be a Falſity: But I aſſure you, there is not any Propoſition in *Euclid* more demonſtrable than this is, as you will find appear, at the End of the *Precepts.*

I have omitted the Tables of the Satellites of *Saturn.* *Firſt*, Becauſe they cannot be ſeen but with a very long Tube, and good Glaſſes; and therefore are not to be purchas'd but at a great Expence. *Secondly*, They would have ſwell'd the Book too much: So that I have contented my ſelf with the firſt Satellite of *Jupiter* only, the Immerſion and Emerſion of which frequently happen, and may be ſeen with a ſmall Teleſcope.

All the Tables I have digeſted in a new, plain, and eaſy Method: And to make the Work

Compleat,

Compleat, I have added the *Logiſtical Logarithms*, with their Conſtruction and Uſe, having continued them to two Hours in Time.

My *Rules* and *Precepts* are all plain and eaſy: For whereas our Authors fall immediately to work in Calculating an Eclipſe, without telling how to find it (which is a very improper way of Teaching,) you will have it otherwiſe here: For firſt, I ſhew you how to find the Ecliptic Boundaries or Limits; then, how to find what Number of Eclipſes there will be in any Year; next, in what Months and Days they fall. Thus having proceeded gradually, I laſt of all, ſhew how to Calculate the ſame Eclipſe when found, for any determinate Latitude or Longitude on the Globe, with their Geometrical Conſtruction, the Laws and Methods of General Eclipſes, the Tranſits, Occultations, &c.

It may be expected, that I ſhould have given a Multitude of Obſervations (as is cuſtomary in Works of this nature) of the Places of all the Planets, Eclipſes, &c. But I have purpoſely omitted them, well knowing, that Authors have often made the Obſervations and their Tables to agree, on purpoſe to ſet the better Gloſs upon them. I chuſe rather to leave the Tryal to their own Obſervations, than to trouble them with any doubtful or unneceſſary Truths.

And as I have now given the World a *Compleat Body*, or *Syſtem of Aſtronomy*, in Two Parts; (the firſt by Inſtrument, or *the true Syſtem of*

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the Planets Demonstrated, a Book in *Quarto*, lately publiſh'd;) ſo in this Treatiſe you have all the moſt nice and exact Rules of Calculation: Which two Books and Inſtruments I adviſe every Student to purchaſe, and which with due Applicacation, will make him a compleat Aſtronomer.

AND farther, I recommend to the Reader's Peruſal, my Sheet of *Eclipſes*, lately publiſh'd; in which are the Types of all the *Eclipſes* that will be Viſible for 35 Years; only you are to underſtand, that the two Total Types of the Moon for the Year 1754, will not be Viſible at *London*, but in *America* only, as you may ſee, if you compare them with the Table, Page 355 of this Vol.

IN the *Appendix* to the *Doctrine of the Sphere* I have given you ſome very uſeful *Tables*, *viz.* the *Latitude* and *Difference* of Meridians of ſome of the moſt Eminent Cities and Towns, with the true times of the Sun's Riſing and Setting, in Hours, Minutes and Seconds, to every Degree of the Sun's Declination North and South, for thirty ſix of the moſt noted Cities in the World. You have likewiſe at one View, all the *Eclipſes* that will happen for thirty nine Years to come, under the Meridian of *London*; which are of Uſe in determining the *Difference* of Meridians between any other Place and that of *London*: As, ſuppoſe in a Ship at Sea, *&c.* you did obſerve the Middle Time of the Moon's Eclipſe, *February* 2, 1729, to be at 6 o'Clock at Night: Look into this Table, and you will find the Middle Time to be at 8 h.

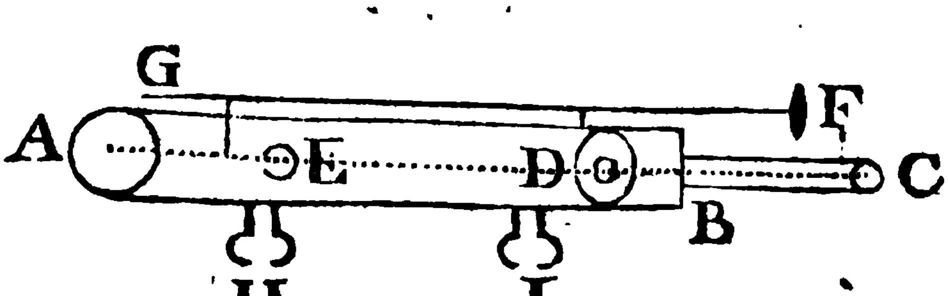
44';

44′; the Difference of Meridians being 2 h. 44′, which in Degrees is 41°; ſo that the Ship is then ſo much to the Weſt of the Meridian of *London*.

In this ſecond Edition I have added a great many Words in the Definitions; and in *Section* 2, 3; ſeveral Schemes, which comprehends all that is uſeful in *Spheric Geometry*. In the *Doctrine of the Sphere*, I have added many uſeful Schemes to illuſtrate the Work, and rectify'd all the Errors and Preſs Faults of the former Edition. And, *Laſtly*, In the *Aſtronomical Precepts*, many New Examples both of the Planets Places, and Eclipſes, with the Tranſit of *Venus* over the Sun. In the Tables I have added the Motion of the Nodes of the Primary Planets to every day in the Year, that now you may confidently affirm that the whole is Compleat and free from Errors; as the Reader will find when he comes to Peruſe it ſeriouſly over, and that he may have Profit with Pleaſure is the hearty Prayer of him who is a well Wiſher to all the Sons of *Urania*.

I shall here crave my Readers Attention a little, while I give ſome Deſcription of the *Gregorian* Reflecting Teleſcope.

This was the Invention of Dr *Gregory*, from him it takes its Name. One of this Size, hand-



ſomly fitted up, will come to about ſix Guineas,

A B is a Braſs Cylinderical Tube about 18 Inches long, and 3,1 Inches Diameter, ſmoaked on the Inſide; D is the poliſhed Metal with a round Hole in the Center; E is the Speculum upon which the Moon's (or other Planets) Reflection from D is thrown; B C is a Braſs Tube of about 3 Inches long, ſcrewed into the other Tube at B; at the End C is a Cavity with a little Pin-hole to ſet your Eye to; ſo that E D and C are in a right Line with their Planes parallel to each other. F G is an endleſs Screw, which moves the Speculum E to a true Diſtance from D, or ſets it to a proper Focus; H and I are two Screws by which the Teleſcope is fixt upon a Ball and Socket in Time of Obſervation, and by this you may ſee the Satellites of *Jupiter*, as well as with a Refracter of 10 Feet long.

THE

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The CONTENTS.

ERRATA to VOL. I.

PAGE 139. for *Prob.* 19, read 18. p. 254, for *Axis* r. *Axis*. p. 356, in the ☉ Vifible Eclipfe *July* 25, r. Digits 3° 51′. p. 392. line 21, for *Bif.* read *Diff.* p. 437. l. 18. under Node, for 1S r. 10 Signs; and l. 23. under Long. for N A, r. N D, and Reduction, add alfo in the fame Page ☉ hourly Motion is 2′ 23″. Page 486 read *The End of the First Volume*.

VOL. II.

PAGE 108, at the Bottom of the Table, in the 2d and 3d Columns, r. Signs 9 add, and Col. 4 and 5, r. Sign 8 add. p. 401. l. 2. for 0 r. 10.

Astronomical Definitions.

A.

ABSIS, the same with *Apsis*, which see.

Absolute Equation, in Astronomy, is the Aggregate or Sum of the Excentric and Optic Equations.

Acherner, a bright fixed Star of the first Magnitude, in *Eridanus*, it is in Dr *Halley's* Catalogue, observed by him at St *Helena* in the Year 1677; it never rises with us at *London*. See its Place in the Catalogue of fixed Stars in the Constellation *Eridanus*.

A *Chronical* rising and setting of the Stars, is, when they rise in the Evening in the eastern Horizon, as the Sun sets; and set in the Evening in the western Horizon with the Sun. [*See the Doctrine of the Sphere.*]

Æras, are certain Periods of Time whence Chronologers begin to compute; and the most eminent *Æras* among them are,

The *Æra* of the World's Creation, which reckons 3949 Years before the Birth of Christ, and which, according to the *Julian* Account, began the 24th Day of *October*.

The *Jewish Æra* begins in Autumn, about the Year of Christ 344.

The *Æra* from the Destruction of *Troy* begins *June* 16.

The *Æra* of *Nabonassar* begins *Feb.* 26, before Christ 747.

The *Æra* of the Olympiads begins from the New Moon in the Summer-Solstice, 777 Years before Christ.

The *Æra* of *Iphitus* is only a Collection of the Olympic Years; these two are the *Æras* chiefly used by the *Greek* Historians.

The *Roman* *Æra* from the Building of the City, begins *April* 21, and is 752 Years before Christ.

The Christian *Æra* from the Birth of Christ, begins *December* 25.

The *Turkish* *Æra*, or the *Hagira*, began the 16th Day of *July*, *Anno Dom.* 622:

The *Æra* of the Death of *Alexander* the Great, is the 12th of *November*, 324 Years before Christ.

The *Julian* *Æra* takes it's name from *Julius Cæsar*'s Reformation of the Calender, which was done 45 Years before Christ, in the 708th Year from the Building of *Rome*, and the 731st Olympiad.

The *Ethiopic*, *Abyssyne*, or, as some call it, the *Dioclesian* *Æra*, others the *Æra* of the Martyrs, because it bore Date with a very severe Persecution; this *Æra* began *August* 29, *A. D.* 284, and in the first Year of the Emperor *Dioclesian*. 'Tis used by the *Ægyptians*, and *Abyssynes*.

The *Persic*, or *Jesdegerdic* *Æra*, takes its Date, either from the Coronation of the last *Persian* King *Jesdegeris*, or from his being conquered by *Ottoman* the *Saracen*, which was *June* 16, *A. D.* 632.

The *Gregorian* *Æra* takes its Name from Pope *Gregory* the XIIIth, and began in *October*, *Anno Domini* 1582, and from the Reformation of the Calendar.

Aldebaran, an *Arabian* Name for a fixed Star of the first Magnitude, situate in the Head of the Constellation called the Bull, and therefore is usually called the Bull's South Eye.

Algeneb, a fixed Star of the second Magnitude, in the right side of *Perseus*.

Algol, or Medusa's Head, a fixed Star of the third Magnitude in the Constellation *Perseus*.

Allioth, the Name of a Star in the Tail of the Great Bear.

Almanack, an *Arabic* Word, and signifies Distribution, or Numeration; whence our Annual Books wherein the Days of the Month, Festivals, Lunations, Motions of the Heavenly Bodies, Eclipses, &c. being set down, are so called.

Almicantariahs,

Almicantariahs, so called by the *Arabians*, are Circles of Altitude parallel to the Horizon, in any of the three Positions of the Heavens, and you may imagine as many as there are Points between the Horizon and Zenith.

Amphiscii, so the Inhabitants of the Torrid Zone are called in respect of their Shadows; because their Shadows fall both ways, *viz.* to the South, (as ours always doth to the northward) when the Sun is beyond them in northern Signs, and to the North when the Sun is to the southward of them in southern Signs.

Amplitude, is an Arch of the Horizon, contained between the rising and setting of the Sun, Moon, or any Star, and the East and West Points of the Horizon, and numbred in Degrees and Minutes, and is always of the same Name with the Declination of the Sun, Moon, or Star, which how to find shall be shewed in the *Doctrine of the Sphere.*

Alpheta, the Name of a fixed Star of the second Magnitude; the same with *Lucida Corona*, in the northern Garland, or Crown; its Longitude 1742 is ♍ 8^{o} $37^{I}\frac{1}{2}$ Latitude 44^{o} 23^{I} N.

Alramech, the *Arabic* Name of a Star, the same with *Arcturus*, which see.

Altitude, is the height of the Sun, Moon or Stars above the Horizon, in an Azimuth-Circle, and is counted in Degrees, Minutes, and Seconds.

Anabibazon, the Dragon's Head, or the northern Node of the Moon is called by this Name.

Andromeda, a northern Constellation consisting of 23 Stars.

Analemma, is a Projection of the Sphere on the Plane of the Meridian, Orthographically made by streight Lines and Ellipses, the Eye being supposed at an infinite Distance, and in the East and West Points of the Horizon.

Analogy, is much the same with Proportion, and is often used for that Word.

Angle, is made by the meeting of two Lines in a Point, and may be of any quantity less than 180^{o}; it is frequently made use of by Astronomers in these particulars, *viz.* Angle of Incidence in a Solar Eclipse is formed by a Line drawn from the Center of a *Penumbra* at the beginning of the Eclipse to the Center of the Earth's Disk; and this is called the first Angle of Incidence. The second is formed by a Line drawn from the Center of the *Penumbra* to the Center of the Disk at the beginning of the central Eclipse; that is, when the Center of the *Penumbra* first touches the Earth's Disk. And the third

Angle of Incidence happens when all the *Penumbra* falls within the Disk, and it is formed by a Line drawn from the Center of the Disk to the Perimeter of the Disk in that Point where the Perimeter of the *Penumbra* last toucheth it in its total Obscurity within the Disk. This third Angle can only happen when the true Latitude of the Moon at the true time of the Conjunction of the Sun and Moon is less than the Difference of the Semidiameter of the *Penumbra* and the Earth's Disk. See my *Uranoscopia.*

Angle of Incidence in the Moon's Eclipse, is formed by a Line drawn from the Center of the Moon, touching the Axis of the Moon's Orb in the Center of the Earth's Shadow, at the times of the beginning or ending of the Eclipse.

Angle of the Sun's Position, is made by an Azimuth-Circle, and the Meridian in the Zenith, the same Azimuth being continued or supposed to pass thro' the Center of the Sun. But more properly by an Hour Circle passing through the Sun's Center, then the Angle at the Pole is the Angle of the Sun's Position.

Angle Parallactic, is made by the Intersection of a Vertical Circle with the Ecliptic thro' the Body of the Sun, Moon or Star. This is of singular use in the Computation of Solar Eclipses.

Angle of Inclination of the Earth's Axis, to the Axis of the Ecliptic is 23° 29', and remains inviolably in all Points of the Earth's Annual Orbit. This Quantity is called by the *Copernicans*, the Earth's Reflection; but by the *Ptolemaics*, the Sun's greatest Declination, or Obliquity of the Ecliptic.

Angle of Evection, is a second Inequality in the Motion of the Moon, by which at her Quarters she is not in that Line which passes thro' the Center of the Earth and Sun, as she is at her Conjunction and Opposition. This Angle in the Quadratures is about 2 Deg. 37'.

Angle of Reflection, is a third Inequality of the Motion of the Moon, and arises from her *Apogeon*, being changed as her System is carried round the Sun by the Earth's Motion. [*See my* Astronomy, *or* System of the Planets demonstrated.] This Angle is greatest, when the Moon is 45 Degrees distant from the Conjunction, Square or Opposition of the Sun, before, and after him; and in Quantity is then 37' 33''.

Angle of Ecliptic and Horizon, is the same with the Altitude of the Nonagesime Degree, and is of great use in the Calculation of Solar Eclipses, &c.

Angle

Angle of Direction, in the New Aſtronomy, is made by the meeting of the Axis of the Moon's Orb with the Axis of the Globe in a Point, and that Point is always at the Center of the Earth's Disk. It is of great uſe in the Geometrical Conſtruction of Solar Eclipſes; and if the Sun be in *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, or *Sagittary*, the Earth's Axis lies to the right Hand of the Axis of the Ecliptic in the Projection: But if the Sun be in the oppoſite Signs at the time of the Eclipſe, *viz.* in *Capricorn*, *Aquarius*, *Piſces*, *Aries*, *Taurus*, *Gemini*, then the ſaid Axis lies to the left Hand.

Angle of Inclination of the Planets Orbits. See *Inclination.*

Annual Equation. See *Equation.*

Annus Magnus, or the great Year, contains 25920 Years, this being that ſpace of time the fixed Stars are in performing one entire Revolution at 50'' *per* Year.

Anomalous Conjunction, is when the two Superiour Planets *Saturn* and *Jupiter* are in Conjunction in *Piſces*, when in the natural Order ſhould have been in *Aries*, but were in *Piſces*, as they did meet ſo in *February* 1643.

Anomaly, in Aſtronomy, is the Diſtance of a Planet in Signs, Degrees, Minutes, and Seconds from the *Aphelial* Point.

Anſes, *or Anſæ*, the ſame with the Ring of *Saturn*; ſo called, becauſe they ſometimes appear like Handles to the Body of the Planet. *Anno*, 1668, *Auguſt* 17th, 11' 30'' P. M. Mr *Hugens* and Mr *Picart*, by the help of a 21 Foot Teleſcope, found the Inclination of the great Diameter of the Ring of *Saturn* with the Equator, to be about 9 Degrees; whence they inferred the Angle of the Plane of the Ring, with that of the Ecliptic, muſt be about 31 Degrees.

Antares, the *Scorpion*'s Heart, a fixed Star of the firſt Magnitude, in the Conſtellation *Scorpio.*

Antæci, of any Place is the Point, the ſame Meredian that is diſtant from the Equator on the South Side, ſo many Degrees as your Place is diſtant from the Equator on the North Side; ſo that the Latitude is the ſame in quantity, but of a contrary Denomination: For their Morning is our Morning, their Noon is our Noon; and their Night, is our Night; but their Spring, is our Autumn, or Fall; their Summer, our Winter; and their longeſt Day, is our ſhorteſt.

Antartic Pole, is the South Pole of the World, being the ſuppoſed Center of the Earth's Axis, and is diametrically oppoſite to the Artic Pole.

Antartic

Antartic Circle, is a lesser Circle of the Sphere, and distant from its Pole 23^{o} 29^{l}.

Antecedentia, things going before, in respect to the Diurnal Motion. In *Astronomy*, it signifies the same as Retrogradation, or the going back of the Planets out of *Aries* into *Pisces*, &c. in their Annual Motion.

Antichones, the same with *Antipodes*.

Antipodes, are those People that walk Feet against Feet, so as a right Line being drawn from the one to the other, shall pass directly thro' the Center of the Earth: Hence it follows, that the quantity of their Seasons are the same with ours; only when it is Summer to the one it is Winter to the other. The Antipodes of *London* fall on the Globe in the unknown southern Parts of the World.

Aphelion is that Point in our System, in which a Planet is at its greatest distance from the Sun, and moves slowest.

Apogeon, is when a Planet is at its greatest Distance from the Earth; the Moon in this Position moves slowest.

Apparent Conjunction, or Place of a Planet, is when the Right Line that is supposed to be drawn through the Center of the Planet, doth not pass through the Center of the Earth, the Cause of which is the Parallax.

Apsis, signifies the two Ends of the tranverse Diameter of the Elipsis in which the Planets move, and denotes as well the *Apogeon* as *Perigeon*.

Aquarius, a Constellation in the Heavens, being the eleventh current Sign in the Zodiac; but the tenth compleat, it is marked thus ♒, and contains 41 Stars. The Sun (apparently) entereth this Sign the 8th or 9th of *January*.

Aquila, or *VulturVolans*, a Constellation in the northern Hemisphere, consisting of 12 Stars, whose Longitude is in *Capricorn*.

Ara, the Altar, a southern Constellation.

Arctophylax. See *Bootes*.

Arctos minor, the same with *Ursa minor*.

Arcturus, a fixed Star of the first Magnitude, placed in the Skirt of *Arctophylos*. Its Longitude is in *Libra*, with 20^{o} 38^{l} North Declination.

Argo Navis, a southern Constellation consisting of 11 Stars; it is in *Cancer*, *Leo*, and *Virgo*.

Argument of Inclination, is an Arch of the Orbit of a Planet intercepted between the Node ascending, and the place of the Planet from the Sun, being numbered according to the Succession of Signs.

Ark

Ark of *Direction*, or Progression in Astronomy, is that Ark of the Zodiac, which a Planet appears to describe when its Motion is forward, according to the Order of the Signs.

Ark of *Retrogradation*, is that which a Planet describes when Retrograde, or moves contrary to the Order of the Signs.

Armillary Sphere, is when the greater and lesser Circles of the Sphere, being made of Brass, Wood, Past-board, *&c.* are put together in their natural Order, and placed in a Frame so as to represent the true Position and Motion of those Circles.

Argument of Latitude, is the distance of the Moon from the North Node, in Signs, Degrees, Minutes and Seconds. It is upon this, that the Latitude of the Moon and Eclipses of the Luminaries depend.

Aries, a Constellation of 21 Stars, lying in the Zodiac in the Figure of a Ram, and is the first Sign, marked thus. ♈

Artic Pole, the North Pole of the World; taking its Name from *Arctos*, the *Bear*; a Constellation in the northern Part of the Heavens.

Artic Circle, is drawn 23° 29' from the Pole, and parallel to the *Equator*.

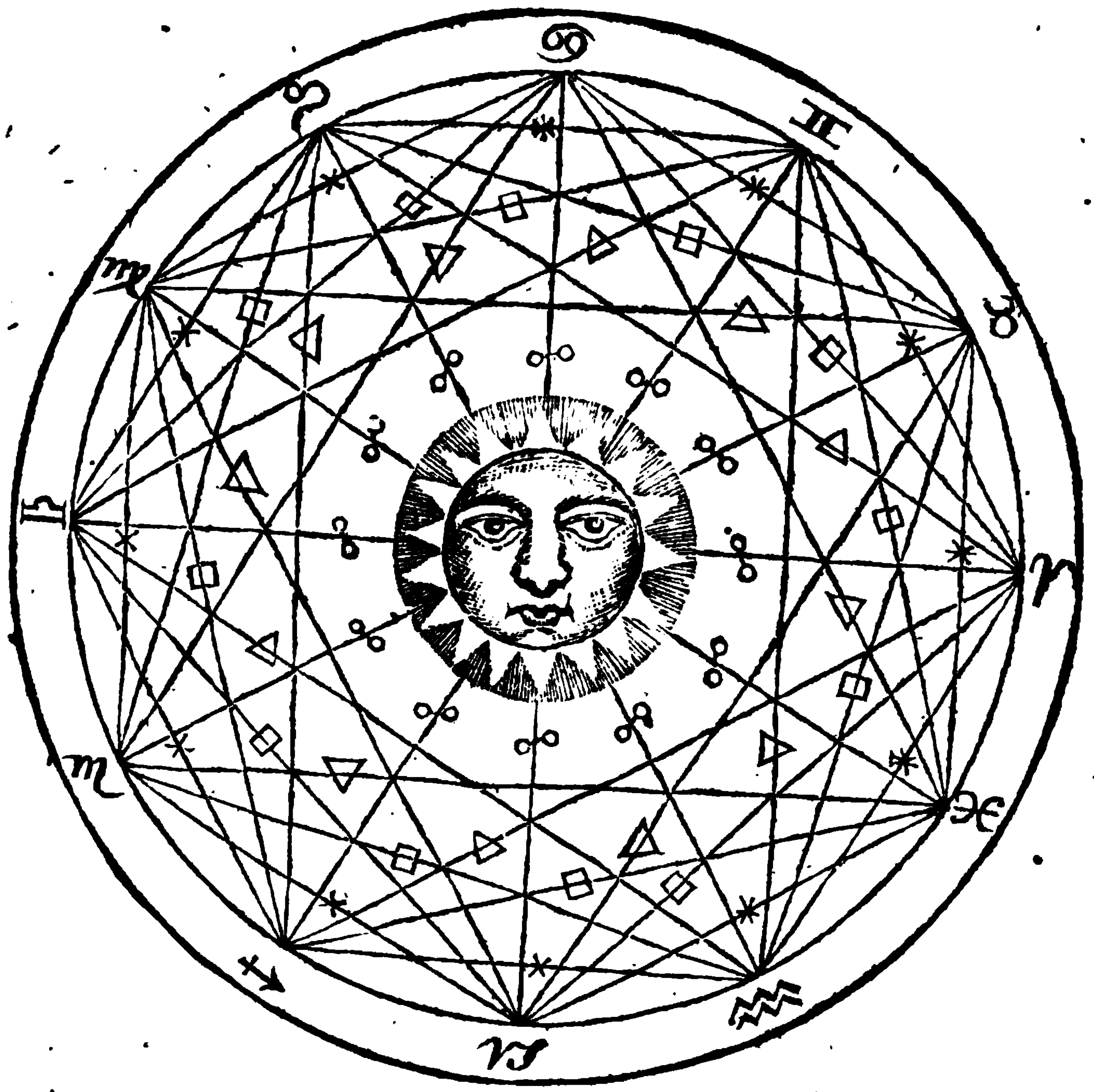
Ascii, are the Inhabitants of the Torrid Zone, which twice a Year have the Sun at Noon in their Zenith, and consequently then their Bodies cast no Shadow, whence comes the Name.

Ascensional Difference, is the difference between the Right and Oblique Ascension, or Descension; or, it is the Space of Time the Sun riseth and setteth before or after Six o'Clock; which is an Arch of the Equinoctial, measured between that Point of it which riseth with the Sun, Moon, or Star, and that Part of it which comes to the Meridian with them.

Ascendent, is the Eastern Part of the Horizon. When the Sun, Moon or Stars are rising, they are said to be on the Cusp of the Ascendent; it is also called the *Eastern Finitor*.

Aspect, from the Latin *Aspicio*, to *behold*, is a Correspondence or Familiarity of two Planets mutually beholding each other with some Ray harmonically considered; or when they are posited at such a certain distance in the Zodiac, wherein they mutually help or afflict one another. Of these Aspects properly there are but four old ones, and eight new ones; to which is added a Conjunction, though improperly called an Aspect. *Kepler* defines an Aspect thus; That it is an Angle formed on the Earth by the luminous Rays of two Planets, efficacious to the stirring up of Nature; for when two Planets are joined with, or beheld of each other, they seminate or breed something in sublunary

nary Bodies according to their own Nature. *See my Syſtem of the Planets Demonſtrated.*



By this Scheme you may perceive a Planet in ♈, caſt his ſextile Dexter to *Aquarius*, and Siniſter to *Gemini*; his ſquare Dexter to *Capricorn*, and ſquare Siniſter to *Cancer*. The trine Dexter to *Sagitarius*, and trine Siniſter to *Leo*; and his Oppoſition to *Libra*, and ſo of the other Signs.

Aſteriſm, from *Aſter*, a *Star*, is the ſame with Conſtellation, or Parcel of fixed Stars, ſuppoſed to repreſent ſome one Image or Figure, deſigned on purpoſe to diſtinguiſh one Star from another.

Aſtronomical Hours begin at the Meridian, and are reckoned from Noon to Noon.

Aſtrolabe, is an Inſtrument ſerving to take the Height of the Sun or Stars. It conſiſts of an entire Circle; the Limb of one quarter thereof is divided into 90 Degrees and decimal Parts, with a moveable Ruler or Label, which turns upon the Center, which

which carries two Sights. At the Zenith is a Ring to hang it by in time of Obſervation, and then you need only turn it to the Sun, that the Rays may paſs free through both the Sights, and the edge of the Lable cuts the Altitude in the Limb.

Aſtronomical Calendar, may be any Inſtrument, or Tables made to ſolve Aſtronomical Problems.

Aſtronomical Place of a Star or Planet, is its Longitude or Place in the Ecliptic, reckoned from the beginning of *Aries* in Conſequentia, or, according to the natural order of the Signs.

Aſtronomy, from *Aſter*, a *Star*, and *Nomos* a *Law*, is a Science by which we are taught the Motions, Magnitudes, and Diſtances, and whatever belongs to the Knowledge of the heavenly Bodies.

Atmoſphere, is the loweſt part of the Region of the Air, with which our Earth is compaſſed all round. Its Height is 47.12 Miles, as I have demonſtrated in my *Syſtem of the Planets*.

Auge, the ſame with *Aphelion*, which ſee.

Aurora, the Morning Twilight which begins to appear when the Sun approacheth within 18° of the Eaſtern Horizon; and this always equal to the Time between the time of Sun-ſetting and the end of Twilight in the Evening.

Aurora Borealis, is a white Pyramidical Glade of Light, appearing like the Tail of a Comet, in theNorthern Hemiſphere.

Auſtral of, or belonging to, the South; alſo *Libra*, *Scorpio*, *Sagittary*, *Capricorn*, *Aquarius*, *Piſces*, are Auſtral Signs; becauſe they lye on the ſouth Side of the Equinoctial.

Autumn, the third Quarter of the Year, beginning when the Sun enters the Sign *Libra*, which is in this Age on *September* 12, or 13, bringing in Harveſt or Fall of the Leaf, and making equal Day and Night.

Aux, the ſame with *Apogeon*.

Axiome, is a Principle in any Science, ſo evident, that it needs nothing but the Light of Reaſon to demonſtrate it.

Axis, of the World, is an imaginary Line, conceived to paſs through the Center of the Earth, from one Pole to another.

Azimuths, or Vertical Circles, are great Circles interſecting each other in the *Zenith* and *Nadir* (as Meridians or Hour-Circles do in the Poles) and cutting the Horizon at Right Angles. The Sun's Azimuth is of great uſe in Dialling and in Navigation, which how to find, I ſhall teach in the *Doctrine of the Sphere* following.

B.

B, In the Astronomical Tables, stands for Bissextile, or Leap-Year.

Babylonish Hours. The *Babylonians*, *Persians*, and *Syrians*, accounted their twenty four Hours of the natural Day to begin from Sun-rising, and to continue till the Sun-setting the next Day. See *Day*.

Basillicus, *Cor Leonis*, a fixed Star of the first Magnitude, in the Constellation *Leo*.

Bear. There are two Constellations of the Stars in the northern Hemisphere, called by this Name, the greater and lesser *Bear*, or *Ursa major* and *minor*. The *Pole-Star* is in the Tail of the little *Bear*.

Binocle, is a kind of Dioptric Telescope, fitted so with two Tubes joining together in one, as that you may see a distant Object with both Eyes.

Biquintile Aspect, is a new Aspect observed by *John Kepler*; it contains $\frac{2}{5}$ parts of the whole Circle = 4s. 24°.

Bissextile, the same as our Leap-Year; and the reason of the Name is, because in every fourth Year they accounted the sixth Day of the Calends of *March* twice; for once in four Years the odd six Hours above 365 Days made up just a whole Day, and that they place next after the twenty fourth Day of *February*, which causeth that Month in Leap-Year to have twenty nine Days; which must be carefully observ'd in the Calculation of the Planets Places.

Bootes. The Name of a northern Constellation of the fixed Stars; of which one in the Skirt of his Coat, is called *Arcturus*, and is of the first Light or Magnitude. See *Arctophylax*. It has fourteen Stars.

Boreal, of, or belonging to the North: So the Boreal Signs are *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*; because they lye on the North Side the Equinoctial.

C

C*Alendar* Astronomical. See Astronomical Calander and Almanack.

Callyopic Period, seventy six Years, or four times nineteen; that is one Revolution of Leap-Years, Multiplyed by one Lunar Cycle. *Callippas*, *Cyzicemis* the Inventor of it, was a famous *Grecian* Astronomer, 350 Years before Christ.

Calends

Calends, so the *Romans* called the first Day of every Month, from the Greek Word, *Caleo*, to call; because anciently counting their Months by the Motion of the Moon, there was a Priest appointed to observe the Times of the New Moon; who having seen it, gave Notice to the President over the Sacrifices, and he called the People together, and declared unto them how they must reckon the Days untill the Nones, pronouncing five Times the Word *Caleo*, if the Nones did happen on the fifth Day, or seven Times, if they happened on the seventh Day of the Month.

Calendar, is the same with Almanack; which see.

Cancer, the *Crab*: In calculating the Planets Places it is in Number 3; or the beginning of it is the third Sign compleat, and is thus marked ♋; It is a Cardinal and Tropical Sign, unto which when the Sun comes, which is about the tenth Day of *June*, he makes the longest Day and shortest Night to all the northern Inhabitants; and he has then the greatest Declination, Amplitude and Altitude.

Canis major, and *Canis minor*; two Constellations, one in the North, and the other in the southern Hemisphere, which rise with the Sun from about *July* the ninth, to *August* the twenty ninth, and gives occasion to that time which is generally very hot and sultry, to be called the *Canicular*, or *Dog-days*. *See the Catalogue of fixed Stars.*

Canicula, the same with *Canis minor*.

Caniculus, or the Dog-Star. See *Canis major*.

Cape'la, a fixed Star of the first Magnitude in the left Shoulder of *Auriga*, in the northern Hemisphere; it is also called the *Goat*, its Astronomical Place is ♊ 18° 15′ in the Year 1742.

Capricorn, the *Goat*, marked thus, ♑ is the ninth compleat Sign in Astronomical Calculations: It is a Cardinal, and the south Tropical Sign, unto which when the Sun comes, which is about the tenth of *December*, he makes the shortest Day and longest Night, to all that inhabit on this side the Equator. The Sun has then the greatest south Declination and Amplitude, but the least Meridian Altitude.

Cardinal Points, are the East, West, North, and South Points of the Compass: And also the Equinoctial and Solstitial Points of the Eclyptic, are called the four Cardinal Points.

Cardinal Signs, are these four; *Aries* ♈, *Cancer* ♋, *Libra* ♎, *Capricorn* ♑.

Cassiopæia, the Name of one of the Constellations of the fixed Stars in the northern Hemisphere, consisting of sixteen

Stars, of which *Schedir* is the brightest: It is placed opposite to the great *Bear*, on the other side the *Pole Star*.

Castor and Pollux, a Constellation of the fixed Stars; the same with *Gemini*, being one of the twelve Signs of the Zodiack.

Catabibazon, the Dragon's Tail is so called because it goes exactly against the Dragon's Head. See *Anibibazon*.

Cauda Lucida, the Lyon's Tail, a fixed Star of the first Magnitude in ♍ 18° 4′ 34″. *Anno* 1742, *Deneb*.

Ceginus, a fixed Star of the third Magnitude, in the left Shoulder of *Bootes*.

Centaure, a southern Constellation in the Sign *Scorpio*.

Center of the Equant in Astronomy, is the same with the upper Focus of the Ellipses, in which the Planets move.

Centrifugal Force, is that Force by which all Bodies which move about any other Body, do endeavour to fly off from the Centre of their Motion in a Tangent to the Periphery of the Curve they describe.

Centripetal Force, is that Force by which any Body moving round another, is drawn down, or tends towards the Center of its Orbit, and is much the same with Gravity. It is by the means of these two Forces, that all the Heavenly Bodies are kept in their Orbits: For by the first, they endeavour to fly off in Tangents; and by the latter they are bent towards the Center in a Curve which is Elliptical.

Cepheus, a Constellation in the northern Hemisphere: Its Astronomical Place is *Aries* and *Taurus*.

Cetus, a southern Constellation, contains twenty Stars, and extends itself to *Pisces*, *Aries*, and *Taurus*.

Charles's Wain, seven Stars in the *Ursa major*, or the great *Bear*.

Chrystalline Heavens, in the Ptolemaic System were two; one served them to explain the slow Motion of the fixed Stars, and caused them (as they thought) to move one Degree eastward in about seventy Years.

Circle of perpetual Apparition, is one of the lesser Circles parallel to the Equator, being described by any point of the Celestial Sphere, which toucheth the northern Point of the Horizon, in any Latitude, and carried about with the Diurnal Motion. All the Stars that are included within this Circle, (that is all that are between it and the elevated Pole) never set, but are always visible above the Horizon.

Circle

Circle of perpetual Occultation, is another lesser Circle at the like distance from the Equator, and contains all those Stars which never appear in that Hemisphere. But the Stars between these two Circles, incessantly rise and set at certain times.

Circles of Altitude. See *Almicanters.*

Circles of Declination, are lesser Circles drawn through any Star, and parallel to the Equinoctial.

Circles of Longitude, are great Circles of the Sphere passing through the Star and the Poles of the Ecliptic, where they determine the Star Longitude, reckoned from the beginning of *Aries.* On these Circles are accounted the Latitudes of the Stars.

Circles of Position, are great Circles of the Sphere, passing by the common Intersection of the Horizon and Meredian, and through any Degree of the Ecliptic, or the Center of any Star, or other point in the Heavens, and are used for finding out the Situation or Position of any Star.

Circular Velocity, is a Term in the new Astronomy, signifying that Velocity or revolving Body, which is measured by the Arch of a Circle.

Circumpolar Stars, are such as are (see Circle of perpetual Apparition) near the Pole, moving round every Day without setting. As the two *Bears*, the *Dragon*, *Cepheus*, *Cassiopia*, *Perseus*, *Hircus*, *Cor Caroli*, *Lynx*, *Cygnus*, &c. never set in the Latitude of *London.*

Comets, are what are commonly called Blazing Stars. The Ancients, especially *Aristotle* and his Followers supposed them to be Meteors, or Exhalations, set on Fire in the highest Region of the Air: The modern Astronomers have found them to be above the Orbit of the Moon, but yet to descend so low, as to move in the Region of the Planets. They appear most commonly with Tails, and the Tail is always turn'd from the Sun. They appear to us at the Earth to move Direct, and sometimes Retrograde. The Periods of some of them that have been observed, have been found to be pretty regular, some compleating one Revolution in seventy five Years and a half, others in one hundred and twenty nine Years, and others in five hundred and seventy five Years: These three are all whose Periods are known, whose Orbits are described in the Copernican System hereunto annexed. They describe Areas by Lines drawn from the Center of the Sun, proportional to the Times, as do all the Planets; and they move in Ellipsis tho' very Eccentric, and are of the same Species with the Planets, and receive all their Light from the Sun.

Copernican

Copernican System, from *Nicholas Copernicus*, a Native of *Thorn*, in *Polish Prussia*, Born *Anno* 1473, died *Anno* 1543, the Reviver of our System.

Cor Caroli, an Extra constellated Star in the northern Hemisphere, situated between the *Coma Berenices*, and *Ursa major*, so called in Honour of King *Charles* the Second. Long. ♍ 19° 40′ Lat. 40° 6′ North, *Anno* 1742.

Cor Hydra, a fix'd Star in the Hydra, a southern Constellation, which see.

Cor Leonis, the Lion's Heart, a fix'd Star, which see.

Corona Borealis, the northern Garland, a Constellation in the northern Hemisphere, which see.

Corona Meridionalis, a southern Constellation of thirteen Stars.

Colures, are two great Circles which intersect one another at right Angles in the Poles of the World, and divide the Zodiack into four equal Parts, and denote the four Seasons of the Year; that passing through *Cancer* and *Capricorn* is called the *Solstitial Colure*; and the other that passes thro' *Aries* and *Libra*, is called the *Equinoctial Colure*.

Combust, is when a Planet is within 8 Degrees 30 Minutes of the Sun, either before or after him.

Commutation, is the Angle at the Sun, made by two Lines, one drawn from the Earth, and the other from a Primary Planet meeting in the Sun's Center.

Complement, a filling up of any Arch or Angle, is what that Arch or Angle wants of 90 Degrees, or that Part by which it exceeds 90 Degrees, to make it up 180 Degrees.

Complement Arithmetical, marked *Co. Ar.* is what any Logarithm wants of 9, and the Unites Place taken from 10; thus the Logarithm 9.768345 being given, its Co. Ar. is 0.231655, and so of any other Logarithm, Sine, Tangent, or Secant, &c. it is of good use when the Radius comes not in the Analogy, as you will find often in the *Doctrine of the Sphere*.

Conjunction, (true,) as when the Sun and Moon (or any other Planet) are exactly in one Degree and Minute of the same Sign, so as a Line supposed to be drawn through their Center, will also pass through the Earth's Center.

——— Apparent is when their Centers lye in a right Line with the Eye of the Observer.

Constellation. See *Asterism*.

Construction, is the drawing of Lines, and forming of Figures, or preparing the Proposition for a Demonstration.

Corollary,

Corollary, is a conſequent Truth, gained from ſome peceding Demonſtration.

Coſmical. Stars are ſaid to riſe coſmically when they riſe in the Morning with the Sun; and to ſet coſmically, when they ſet as the Sun riſeth. In the Doctrine of the Sphere I have ſhewed how to calculate the coſmical Riſing and Setting of any of the heavenly Bodies.

Conſequentia, following in reſpect of the Diurnal Motion. In Aſtronomy, 'tis when the Planets move forward according to the order of the Signs, from *Aries* to *Taurus*, &c.

Corvus, a ſouthern Conſtellation of ſeven Stars.

Crater, the Name of one of the ſouthern Conſtellations of eleven Stars.

Croſſiers, are four Stars in the form of a Croſs which ſerve to ſhew thoſe that ſail in the ſouthern Hemiſphere, the Antartic Pole.

Culminating, or *Culmen Cœli*, the higheſt Point in Heaven, that any Planet or Star can riſe to in any Latitude; and when a Star comes to the Meridian of any Place, 'tis ſaid to culminate: Alſo the Southing of the Moon and Stars are taken for the ſame thing.

Cycle of the Moon, is a Revolution of nineteen Years, in which Time the Conjunctions and Lunar Aſpects are nearly the ſame they were nineteen Years before. It is alſo called the *Prime* or *Golden Number.*

Cycle of Indiction, is a Revolution of fifteen Years, of uſe only at *Rome.* This has nothing to do with the heavenly Motion, being eſtabliſhed by *Conſtantine*, *Anno Domini* 312, *September* 24, who ſubſtituted them in the room of the Olympiads. They are ſo called, becauſe they denoted the Year that Tribute was to be paid.

Cycle of Eaſter, is a Revolution of 532 Years found by the Multiplication of the ſolar Cycle 28, by the Lunar 19: For in that time do the Holy Feaſt of *Eaſter*, and all things depending thereon, return to the ſame ſtate again. *See Dionyſian Period.*

Cygnus, the *Swan*, a Conſtellation in the northern Hemiſphere, which ſee in the Catalogue of fixed Stars.

D

DAILY *Motion.* See *Diurnal.*

Day Natural, determined by the Sun's Motion (according to appearance) round the Earth in near 24 Hours, though really it is the Earth round her own Axis from the Weſt to

the

the East in near that Time: It is also called *Civil*, because it is by divers Nations reckoned divers ways. The *Babylonians* begin to account their Day from the Sun-rising; as likewise do the Inhabitants of *Nuremburg* in *Germany*; the *Athenians*, *Jews* and *Italians* from Sun-setting; the *Egyptians* and *English* at Midnight: But Astronomers begin the Day at Noon; to which time are the places of all the Planets supputated in our Ephemerides.

Day Artificial, is the time between the Sun's rising and setting; to which is opposed Night, which is the Time that the Sun is under the Horizon.

Declination of the Sun, Moon, and Stars, are, their distance from the Equinoctial, reckoned on a Circle of Longitude in Degrees and Minutes between the Star and Equinoctial, and is either North or South. The Sun's greatest Declination is 23° 29′, the Moon's 28° 46′ 20″, but the Moon's is not always so much when she is in *Cancer* or *Capricorn*; but only when her Nodes are in *Aries* and *Libra*; for which purpose I have given you a Table of the Inclination of the Moon's Orb with the Equinoctial.

Dechotomized, the Moon when in the Quadratures is exactly half Illuminated, or Dechotomized.

Definition, is the unfolding, or explicating of the Nature and Affection of a thing.

Degree, is the 360th Part of a Circle, or the 30th Part of a Sign.

Degree of a great Circle of the Sphere, is the 360th Part thereof, for any great Circle, as the Meridian, Equinoctial, &c. being divided either actually or by Supposition into 360 equal Parts, those Parts are called Degrees; it is subdivided into 60 Parts, called *Minutes*, and each of them again into 60 Parts more, called *Seconds*, and so into *Thirds*, &c.

Degree of a great Circle on the Surface of the Earth and Sea, is according to Mr *Norwood*'s Experiment 367196 Feet, which divided by 5280 the Feet in an *English* Miles, Quoteth 69.54 Miles. Which agrees very well with the Experiment made by the *French* Mathematicians.

Delphinus, the Dolphin, a Constellation in the northern Hemsphere containing 10 Stars.

Demonstration, is the proving of a thing by Definition and Axiome; and so from several Arguments drawing a Conclusion, that it has that Affection the Proposition did assert.

Deneb,

Deneb, a fixed Star in the Tail of the Lion.

Depression of the Pole, so many Degrees as you sail or travel from the Pole towards the Equator, you are said to depress the Pole.

Descension, of the Heavenly Bodies, is their going down, or setting in the western Horizon.

Dexter Aspects, is made contrary to the Succession of the Sign, as from ♈ to ♒, ♐, *&c.*

Diacentros, is a Word used by *Kepler*, to signify the shortest Diameter of the Elliptical Orbit of any Planet.

Digit, properly a Finger's Breadth; but in Astronomy, it is the twelfth Part of the Sun's Diameter, made use of in Eclipses; but the Moon's Digits may amount to about 23. All above 12 shew how far the Shadow of the Earth is over the Shadow of the Moon.

Dihelios, in the Elliptical Astronomy, is that Ordinate of the Ellipsis, that passes through that Focus in which the Sun is supposed to be placed. *Kepler*.

Dionysian Period, is the same with Cycle of *Easter*, to find which, always add 457, (that being the Cycle at the Birth of Christ) to the present Year of our Lord, and divide the Sum by 532, the Remainder is the Victorian, or Dionysian Period.

Direct, a Planet is said to move Direct, when it moves from *Aries* to *Taurus*, &c. The Sun and Moon are always so; but the Primary Planets are sometimes Retrograde at the Earth; for a Demonstration of which see my *Astronomy*, or *System of the Planets demonstrated.*

Disk of the Sun and Moon, are their round Phases or Faces, which at their great Distance from us appear to us plain, flat, or like Dishes.

Disk of the Earth, is the difference between the Horizontal Parallax of the Sun 10″, and the Horizontal Parallax of the Moon (which is different at different Times) which is demonstrated by the Diagram of *Hipparchus*, and used in the Geometrical Construction of Solar Eclipses, as I shall shew at large in the following Sheets.

Diurnal, of or belonging to the Day: The Diurnal Motions of the Planets in Longitude and Latitude are what they move from the Noon of one Day, to the Noon of the next Day, which Quantities you may see in the following Astronomical Tables.

Dodecatemory, the twelve Signs of the Zodiack, *Aries*, *Taurus*, &c. are so called because each of them is the twelfth Part of the Zodiac.

Dog-Days. See *Canis major.*

Dominical Letter, one of the first seven Letters of the Alphabet, wherewith the *Sundays* are marked in the Almanacks with a Red Letter throughout the Year. In my *System of the Planets demonstrated* I have given new Numbers which supply the use of the Dominical Letters, for finding what Day of the Week any Day of the Month is for ever.

Dragon's-Head, or *Ascending Node*, is the North Intersection of the Moon's Orb with the Ecliptic; to which when the Moon comes, she has no Latitude. It is charactered thus ☊.

Dragon's-Tail, or *Descending Node*, is the South Intersection of the Moon's Orb with the Ecliptic, to which when the Moon comes, she has again no Latitude. It is also called *Catabibazon*, and is diametrically opposite to the *Dragon's-Head*; and their mean Motion is Retrograde, as may be seen by the following Tables. It is charactered thus ☋.

Dragon, is a northern Constellation, which see in the Catalogue of the fixed Stars.

Duplicate Ratio, is no more than the Proportion of the first to the third, in three continual Proportionals.

Duration, of an Eclipse, Occultation, &c. is the Time it continues to be Eclipsed, or hid from our Sight.

E.

EArth. In my *System of the Planets demonstrated* I have proved, that the Earth has an Annual and Diurnal Motion, and that the Sun is at Rest in the Center of the Universe. Dr *Gregory* saith, that the Earth's Axis keeps near parallel to it self in its Annual Revolution round the Sun; and that by reason of its swift Diurnal Motion, puts on the Figure of an Oblate Spheroid, swelling out towards the Equatorial Parts, and contracted towards the Pole; so that the Diameter of it at the Equator is longer than the Axis by 63 Miles: For Sir *Isaac Newton* proved, that the Polar Diameter or Axis, is to the Equatorial one, as 698 to 692. Therefore according to *Norwood*'s Measure, I have calculated the Earth's

Circumference	25035.84	*English* Miles.
Diameter	7969.16	
Height of the Earth's Atmosphere	47.12	

The Cone of the Atmosphere and Shadow does not reach so far as the Orb of *Mars.*

Eccentricity,

Eccentricity, is the distance between the Center of the Ellipsis and the *Focus*. Here Note, that the Sun is seated upon the lower *Focus* of the Ellipsis in the System of the six Primary Planets, and the Earth upon the lower *Focus* in the Moon's System.

Eccentric Place of a Planet, is the same with the Orbit-Place.

Eclipse, is a Deprivation of Light. The Eclipse of the Sun (or truly the Earth) is caused by the Interposition of the Moon's dark Body between the Sun and our Sight, and can never happen but at the New Moon, when the Sun and Moon are less than 18° from the Moon's Nodes; and by reason of the nearness of the Moon to the Earth, and sudden Change in Parallax, the same Solar Eclipse shall be Total to one Part of the Earth, to another Partial, and to another Inhabitant no Eclipse at all.

The Moon's Eclipse is real, and universal; and is caused by the Interposition of the Earth between the Sun and Moon; and this can never happen but at the Full Moon, within less than 12° of her Nodes; for the Moon being an Opake Body, borrowing all her Light from the Sun, is then deprived of that borrowed Light, and so is Eclipsed. There can never happen more than six, nor less than two Eclipses in one Year; and when two, they are both of the Sun.

Ecliptic, is one of the six great Circles of the Sphere, intersecting the Equinoctial in two opposite Points, *Aries* and *Libra*, making an Angle therewith of 23° 29′, called, the *Obliquity of the Ecliptic*, equal to the Sun's greatest Declination: In this Circle (according to appearance) is the Sun always found, and the Earth truly, in the opposite Sign Degree and Minute: It is divided into 12 equal Parts called *Signs*, and every Sign into 30°, every Degree into 60′, and every Minute into 60″. It also toucheth the two Tropics in the very beginning of *Cancer* and *Capricorn*.

Elevation of the Pole, is an Arch of the Meridian comprehended between the Pole and the Horizon, which is always equal to the Arch of the Meridian between the Zenith and Equinoctial; these being the same with the Latitude of the Place of Habitation.

Elongation, signifies the Removal of a Planet to the furthest Distance it can from the Sun, as it appears to an Eye placed on the Earth; this is most usually taken notice of in *Venus* and *Mercury*. *Mercury*'s Elongation can never be more than 28° 21′ 8″, nor less than 17° 35′ 42″; and *Venus* can never be

more than 47° 38′ 35″ elongated from the Sun, nor less than 44° 56′ 14″. See my *Uranoscopia* page 63.

Ember-Weeks, are those Weeks in which the *Ember-Days* fall; they were of great Antiquity in the Church in the Primitive Times, and are four in Number, and were therefore called by the ancient Fathers, *Quatuor Anni Tempora*, the four Cardinal Seasons on which the Circles of the Year turn: They are the *Wednesdays*, *Fridays*, and *Saturdays* next after *Quadragesima-Sunday*, after *Whitsunday*, after *Holy-Rood* Day *September* 14, and after St *Lucy*'s Day *December* 13: They were at first ordained for Quarterly Seasons of Devotion; wherein as the first Fruits of every Season, the antient Christians put up their Prayers and Supplications to Almighty God, that thereby the whole Year, and every of its four Parts might be blessed; and used to eat nothing till the Eventide, and then only a Cake baked under the Embers, or Ashes, which they called *Ember-Bread*; these *Ember-Weeks* are chiefly taken notice of on the Account of the Ordination of Priests and Deacons; because the Canon now appoints the *Sundays* next succeeding the *Ember-Weeks* for the solemn Times of Ordination; though the Bishops, if they please, may ordain on any *Sunday* or Holiday.

Embolism, is the excess of the Solar Year above the *Lunar*, whereby the Lunations happen every subsequent Year, eleven Days sooner than in the foregoing; which when they amount to 30 Days make a New Month called the *Embolismical* Lunation, or Embolismatical Month, which must be added to make the common Lunar Year equal to the Solar.

Emersion, is the Time when any Planet that is Eclipsed, begins to recover its Light again: It is most used in the Eclipses of *Saturn* and *Jupiter*'s Satellites.

Emergent, the same with Emersion.

Engonasus, Hercules, a northern Constellation.

Enneadecaterides, the same with Golden Number.

Epact, from *Epiago*, a going round; is a Number that is the difference between the common Solar Year 365 d. 5 h. 49′ 23″, and the mean Lunar Year 354 d. 8 h. 49′ 12″ which is 10 d. 21 h. 00′ 11″; but to avoid Fractions, the Number 11 Days is made use of, which shews that the Moon changes sooner in any Month this present Year than she did in the same Month the last Year; therefore it is of good use to find the Days of the New and Full Moon's Age, &c. as I shall shew in the *Doctrine of the Sphere*.

Ephemeris, a Diary or Day-Book; amongst Astronomers, *Ephemerides*, the same with Almanack, which see.

Epocha,

Epocha the same with *Æra*, which see.

Equation, is the difference between the Planets mean and true Place; for if the mean Anomaly be less than 6 Signs, the Equation subtracted; or if the Mean Anomaly be more than 6 Signs, the Equation added to the mean Place, the Sum or Difference is the Eccentric or Orbit-place of the Planet.

Equation of Time, or of Natural Days, consists of two Parts; the first Part depends on the Sun's Place, and is the Difference between that and his Right Ascension, which in the first and third Quadrants of the Ecliptic is to be added; but in the second and fourth to be subtracted; the Sum or Difference is the first part of the Equation of Time. The second Part depends on the Earth's Anomaly, and is only the Sun's (or Earth's) Equation reduced into Time; which, if the Mean Anomaly be less than 6 Signs, it addeth; if more, it subtracteth to, or from the Equal Time, to gain the Apparent, if both these Parts, add, or both subtract their Sum, otherwise their Difference is the absolute Equation of Time; which applied to the Equal Time according to the greater Title, gives the Apparent Time.

Equiculus, or *Equus minor*, is a Constellation in the northern Hemisphere. See the *Catalogue of fixed Stars*.

Equator. *See* Equinoctial.

Equinoctial, in the Heavens, or Equator on the Earth, is one of the six great Circles of the Sphere, whose Poles are the Poles of the World. It divides the Globe into two equal Hemispheres, *viz.* North and South, and passeth thro' the East and West Points of the Horizon; and at the Meridian it is always raised so much as is the Complement of the Latitude of the Place where you are; which Arch is also equal to the Arch of the Meridian between the Zenith of any Place or Pole. Every 15° of this Circle, that passeth by the Meridian by the Diurnal Motion, is equal to one Hour in Time. Also when the Sun (apparently) comes to this Circle, which is about the 9th of *March*, and 12th of *September*, he makes the Days and Nights equal all the World over, except under the Poles.

Equinoxes, are the precise times in which the Sun, or Earth enters into the first Points of *Aries* and *Libra*; and this they do twice a Year, about the 9th of *March* and 12th of *September*, which times are called the *Vernal* and *Autumnal Equinoxes*, making then the Days and Nights equal: And Astronomers have found by Observation, that the Space of Time from the *Vernal Equinox*, to the Autumnal are 7 d. 18 h. 52′ longer than the time from the Autumnal to the Vernal: From which they come

come to know, that the Earth did not move or keep an equal Pace in all parts of its Orbit.

Ericthonius, the same with *Auriga*, a northern Constellation.

Eridanus, the River, a southern Constellation.

Erratic Stars, are the seven Planets; because they wander up and down the Zodiac: They are also called *Errones*.

Errones, or *Erratic*, or wandering Stars, the same with the Planets.

Estival Orient. See *Orient*.

Evection. See *Angle of Evection*.

Explode, to hiss off the Stage; that is, any thing that doth not agree with sound Philosophy, or that will not bear a Mathematical Demonstration, is said to be exploded.

F.

Faculæ, are certain bright or shining Parts, which the modern Astronomers have sometimes observed upon, or about the Surface of the Sun; but they are but very seldom seen.

Falcated, the Moon, (or any Planet) appears falcated, when the enlightened parts are in the Form of a Sickle; as the Moon doth in the first and last Quarters.

Fasciæ of *Mars*, are certain Rows of Spots, parallel to the Equator of that Planet, which look like Swathes or Fillets round about his Body.

Finitor, the same with Horizon; because the Horizon finishes or terminates your Sight, View, or Prospect.

Firmament, by some Astronomers is taken for the Orb of the fixed Stars, or an eighth Heaven; but more properly 'tis that Space which is expanded or arched over us above in the Heavens.

First Mover. See *Primum mobile*.

Fixed Signs of the Zodiac, according to some are, *Taurus*, *Leo*, *Scorpio*, and *Aquarius*; and they are so called, because the Sun (apparently) passes them respectively in the middle of each Quarter, when that particular Season is more settled and fixed than under the Sign that begins or ends it.

Fixed Stars, are such as do not, like the Planets or Erratic Stars, change their Positions or Distances in respect of one another; and because their Annual Motion is nothing but the Recession of the Equinox $= 50''$; therefore they are said to be fixed.

fixed. They move upon the Poles of the Ecliptic, and therefore never alter their Latitudes. Their distance from us is so very great, that no Parallax in them can be discovered, as Dr *Halley* assured me; tho' Mr *Flamstead* wrote to Dr *Wallis* in the Year 1698, and assured him, that he had discovered a sensible Parallax in the Earth's Annual Orbit in respect of the fixed Stars. It has been a Question amongst the Ancients, whether the Light of the fixed Stars was innate; given them by Almighty God at their Creation, or borrowed from the Sun: The first seems to carry most of Truth in it; and our Modern Astronomers do now conclude each fixed Star to be the Head and Chief Part of a distinct Mundane System, having their several Planets carried about them. If so, what a vast Expansion must there be in the Interstellar, or without our Planetary System, to contain so many vast Bodies? Their Scintillation, or Sparkling (*Gassendus* and *Hevelius*) think to be caused by that Native and Primogenial Light they are endowed with, coming to our Sight at so immense a Distance, and passing thro' different Mediums, which by a constant Evibration of lucid Matter, appears to our Sight to twinkle; which is not observed in any of the Planets. As for their Number, it is what I shall not pretend to give; but as many as are useful and of note, you will find in the following Catalogue.

Fomahant, a fixed Star of the first Magnitude in the Mouth of the southern Fish, its Longitude *Anno* 1742, is ♓ 0° 12′ 20″, Latitude 21° 4′ 54″ South.

G.

G*Alaxy*, or *Via Lactea*. See *Milky-Way*.

Gemini, the Twins; the third Sign in the Zodiac, thus charactered ♊; but in all Astronomical Calculations it is numbred with 2.

Geocentric Place of a Planet, is that which is seen from the Earth.

Gibbous, is a Term used in reference to the enlighten'd Parts of the Moon, while she is moving from the first Quarter to the last Quarter; for all that Time the light part is Convex or Gibbous.

Golden Number, is the same with Cycle of the Moon; which see.

Great Bear, a northern Constellation.

Gregorian Year, is the Reformation of the Calender by Pope *Gregory* XIII, in the Year 1582, and is in this Age 11 Days before

fore the *Old Stile* used by us in *England.* It is also called the *New Stile*; and the Places that reckon by the *Gregorian* or *New Stile*, are, *France*, *Spain*, *Portugal*, *Italy*; and in *Germany*, all the Popish Electors and Princes, and all *Poland*.

H.

Hagira. See the Turkish *Æra*.

Height of the Pole. See *Altitude*.

Helice major or *minor*, the same with *Ursa major* and *minor*.

Heliacal Rising, is when a Star having been under the Sun's Beams, gets from the same so as to be seen again in the Morning before the Sun.

Heliacal Setting, is when a Star by the near Approach of the Sun, first becomes inconspicuous. The Moon may be seen nearer the Sun; that is, at a less distance from him than any other Planet or Star; because she is nearer to us than any of the rest; and also because her apparent Diameter is greater; so that she may be seen at about 17 Degrees from the Sun, when the other Planets cannot be seen till they are near a Sign distant from him.

Heliocentric Place, is, that it would appear to an Eye at the Sun; for the Planets would always appear Direct there, and the Heliocentric Latitude is the same with the Inclination of the Orb with the Ecliptic: For the Quantity of each Planet's Inclination, or the greatest Angles you will find in the following Tables.

Hemisphere, is the half of a Globe or Sphere, when 'tis supposed to be cut thro' the Center in the Plain of one of its great Circles. Thus, the Equator divides the Terrestrial Globe into the North and South Hemispheres; and the Equinoctial the Heavens after the same manner. The Horizon also divides the Earth into two Hemispheres, the one light, and the other dark, according as the Sun is above or below that Circle.

Heniochus, one of the northern Constellations.

Hesperus, the Name of *Venus*, when she is the Evening Star.

Heterocii, are such Inhabitants of the Earth, as have their Shadow falling but one way, as those who live between the Tropics and Polar Circles (*i. e.* in the two Temperate Zones) whose Shadow at Noon is to the northward, to those that live in the north Temperate Zone, and southward to those that live in the south Temperate Zone.

Hircus,

Hircus, a Name given by some Writers, to a sort of a Comet, encompassed with a kind of Main, seeming to be rough and hairy, by reason of its Rays appearing like Hairs. It is also sometimes round without any Train or Brush.

Horizon, is one of the six great Circles of the Sphere, which divides the Heavens and the Earth into two equal Parts, or Hemispheres, distinguishing the upper from the lower: It is either Sensible or Apparent; or Rational or True Horizon. The Sensible or Visible Horizon, is that Circle which limits our Sight, and may be conceived to be made by some great Plane, on the Surface of the Sea. It determines the Rising and Setting of the Sun, Moon and Stars, in any particular Latitude.

The Rational, Real, or True Horizon, is a Circle which encompasses the Earth exactly in the Middle, and whose Poles are the *Zenith* and *Nadir*.

Horologiography, the Art of making Dials, Clocks, &c. to shew the Hour of the Day.

Horometry, the Art of Measuring and Dividing the Hours, and keeping account of Time.

Horoscope, the same with *Ascendent*, which see.

Hour Circles, the same with Meridians, or great Circles meeting in the Poles of the World, and crossing the Equinoctial at right Angles, they are drawn through every 15 Degrees of the Equinoctial.

Hour is the 24th part of a Natural Day, containing 60 Minutes, and each Minute 60 Seconds, These are Astronomical Hours, which always begin at the Meridian, and are reckoned from Noon to Noon.

Hydra, a southern Constellation, and imagined to represent a Water-Serpent.

Hyemal Solstice. See *Solstice*.

Hypothesis, the same with *System*, which see.

I.

IDes, of a Month among the *Romans*, were the Days after the Nones were out. They commonly fell out on the 13th of every Month, except in *March*, *May*, *July* and *October*, (which they called full Months, as all others were called hollow) for then they were on the 15th; because in those Months the Nones were on the 7th.

Jewish Hours, are the 24 Hours of the Day, accounting from Sun setting to Sun setting again, much after the manner as the *Italians* do now.

Illuminative Month, is that Space of Time that the Moon is viſible, to be ſeen betwixt one Conjunction and another.

Immerſion of a Star, is when it approaches ſo near the Sun, as to be hidden in its Beams. The beginning of an Eclipſe is alſo ſo called; as alſo the Satellites of *Saturn* and *Jupiter*, when they enter into their Shadows, are called *Immerſions*.

Inclination, of the Planes of the Orbits of the Planets to the Plane of the Ecliptic, are the ſame with *Heliocentric Latitudes*; which ſee.

Inclination of the Axis of the Earth, is the Angle which it makes with the Axis of the Ecliptic $= 23^{\circ}\ 29'$.

Inequality of Natural Days. See *Equation*.

Informed Stars, are ſuch of the fixed Stars, as are not caſt into, or ranged under any Form.

Ingreſs, is the Sun's Entrance into any Sign, or other part of the Ecliptic.

Intercalary Day, the odd Day made up of the ſix Hours every fourth Year, is put in the next after the 24th Day of *February*, and that occaſions the Leap-Year.

Interlunium, when the Moon has no Face or Appearance, as being in Conjunction with the Sun (*i. e.*) *New Moon*.

Interſteller, a Word uſed by ſome Authors to expreſs thoſe parts of the Univerſe that are without, and beyond our Solar Syſtem, moving round each fixed Star, as the Center of their Motion, as the Sun is of ours. And if it be true (as 'tis not impoſſible, but each fixed Star may thus be a Sun to ſome habitable Orbs that may move round it), the Interſtellar World will be infinitely the greater part of the Univerſe.

Julian Year, is the old Account of the Year, inſtituted by *Julius Cæſar*, which to this Day we uſe in *England*, and moſt *Proteſtant* Countries, and call it the *Old Stile*, in contradiction to the *New Stile*, or *Gregorian Account*, which ſee. This *Julian* Year is 365 Days, 6 Hours long, but 'tis too much by $10'\ 10''$, which in about 134 Years will amount to one whole Day.

Julian Period, is a Cycle of 7980 Years, produced by the Multiplication of three Cycles, *viz.* that of the Sun 28, of the Moon 19, and that of the *Roman* Indiction of 15 Years. This was the Invention of *Julius Scaliger*, who fixed the beginning of it 764 Years before the Creation; ſo that at the Birth of Chriſt it was 4713; therefore if to the current Year of Chriſt you add 4713, the Sum will be the Year of the *Julian* Period; and from the Year of the *Julian* Period ſubtract 4713, there will remain the Year of the Chriſtian *Æra*; or the Year of

of the *Julian* Period may be found to any Year of Christ, by fixed Multiplicators; which may be found thus, *viz.* There must be such a Number found that being multiplied by the Product of 19 by 15, as that Product when divided by 28, the Remainder will be 1. This Number will be 17; then $19 \times 15 = 285 \times 17 = 4845$, the common Multiplicator.

Secondly, We must find a Number, which being multiplied by the Product of 28 by 15, and that Product divided by 19, leaves for the Remainder 1, and this Number is 10; for $28 \times 15 = 420 \times 10 = 4200$ the common Multiplicator.

Thirdly, We must find a Number, that being multiplied by the Product of 28 by 19, and that Product divided by 15, leaves 1. This Number is 13. Then $28 \times 19 = 532 \times 13 = 6916$, the Multiplicator sought. Then to find the Year of the *Julian* Period for any Year of Christ, this is the Rule; Multiply

the fixed Number $\begin{Bmatrix} 4845 \\ 4200 \\ 6916 \end{Bmatrix}$ by the Cycle of the $\begin{Bmatrix} \text{Sun,} \\ \text{Moon,} \\ \text{Indiction,} \end{Bmatrix}$

the Sum of these Products divided by 7980, the Remainder is the Year of the *Julian* Period to the given Year of Christ.

Example. This Year 1724, you will find the Year of the *Julian* Period to be 6455.

Jupiter, is the highest Planet in our System, except *Saturn*; and his Motion round the Sun is so adjusted, that the Square of the time of his periodical Revolutions is as the Cubes of his mean Distance from the Sun. And the same immutable Law is observed throughout all the Planetary System; which was first discovered by *Kepler*, and since demonstrated by the great Sir *Isaac Newton.* Mr *Flamsteed* and Dr *Halley* having found by Observation, that ♃ moved too slow by all our Astronomical Tables; which Defect I have taken into Consideration, and adjusted the Motion in the following Tables. *Jupiter* is called *Jove*, *Phaëton*, *Zeus*. *Jupiter* is thus Marked ♃.

K.

KAlender. See *Calender*.

Kalends. See *Calends*.

Kepler, *John*, of *Wittemberg* in *Germany*, flourished in the Year 1620, was Mathematician to three Emperors, and an ex-

cellent Astronomer; he was the first that discovered the *Elliptic* Orbits of the Planets, and that the Squares of their Periodical Times are as the Cubes of their mean Distances, from the Sun and the general Phænomena of Solar Eclipses; in the Year 1618 he set forth his *Epitome Astronomiæ Copernicanæ: Ephemerides, De Hermonia Mundi, Mysterium Cosmographicum,* with many other valuable Pieces in Astronomy; as *De Motibus Stellæ Martis.*

L.

Latitude, in Astronomy, is the distance of a Star or Planet from the Ecliptic, measured upon an Arch of a Circle of Longitude from the Ecliptic towards the Poles thereof; but the Geocentric Latitude is the Angle that the Planets Latitude appears under to any Eye on the Earth.

Latitude, in Geography, or on the Earth, is the Height of the Pole of the World above the Horizon, which is always equal to the Arch of the Meridian between the Zenith and Equinoctial.

Leap-Year. The same with *Bissextile*, which see.

Lemma, is the Demonstration of something premised, in order to shorten a following Demonstration.

Leo, the *Lion*, the fifth Sign in the Zodiac, character'd thus ♌, unto which the Sun comes about the 12th Day of *July*; and in Astronomical Calculations is numbred with the Figure 4.

Lesser Circles of the Sphere, are those whose Planes do not pass thro' the Center of the Sphere; and which do not divide the Globe into two equal Parts; but are parallel to greater Circles; as the Tropics and Polar Circles, and all Parallels of Declination and Altitude.

Letter Dominical. See *Dominical Letter.*

Libra, one of the 12 Signs of the Zodiac, character'd thus ♎, unto which the Sun apparently comes about the 12th of *September*, making equal Day and Night; and in Astronomical Calculations is numbred with the Figure 6. All the other being Annuals.

Libration of the Moon, is of three Kinds: *First*, in Longitude, which is a Motion arising from the Plane of that Meridian of the Moon, (which is always nearly turned towards us) being directed not to the Earth, but towards the other Focus of the Moon's Ecliptical Orbit; and so to an Eye at the Earth, she seems to librate too and again. *Secondly*, in Latitude, which arises

arises from hence, that her Axis not being perpendicular to the Plane of her Orbit, but inclin'd to it, sometimes one of her Poles, and sometimes the other will nod, or dip a little towards the Earth. *Thirdly*, the Moon has a kind of a Libration, by which it happens, that tho' one part of her is not really obverted, or turn'd to our Earth, as in the former Librations; yet another is illuminated by the Sun: For since her Axis is perpendicular nearly to the Plane of the Ecliptic, when she is at her greatest South Limit, so Parts adjacent to her North Pole will be illuminated by the Sun, while on the contrary the South Pole will be in darkness; and these Librations will be compleated in her Synodical Month.

Limit of a Planet, is the greatest Heliocentric Latitude; which see.

Limit, for Eclipses of the Sun and Moon, are certain Distances of the New and Full Moons, from the Nodes of the Moon; in which the Eclipses always happen, and the Limits of the Moon's Eclipse are 12° 2′ 9″, and her utmost Latitude 62′ 25″; that is, if her Distance from either Node at the Full Moon be more than 12° 2′ 9″, her Latitude will exceed 62′ 25″; therefore there can be no Eclipse at that time. The Limit, or Boundaries of the Sun's Eclipses are, 18° 20′ 8″, and the Latitude of the Moon then 1° 34′ 16″. These are the greatest Limits: But there are yet two other Extreams, which I call the *least Limits*; that is, if the Distance from the Nodes be such, it is possible there may at that time be no Eclipse; and they are these;

Least Limits of	Moon	10°	19′	17″	Lat.	53′	41″
	Sun	16	35	5	Lat.	85	32

The Cause of these two Extreams of the Limit, is, the different Distances of the Sun and Moon from the Earth at different times.

Line of mean Motion of a Planet, is drawn from the upper Focus thro' the Planet, and continued amongst the fixed Stars.

Line of true Motion, is drawn from the Sun on the lower Focus to the Planet, and continued amongst the fixed Stars.

Line of Nodes, is drawn from one Node to the other.

Logarithms, (from *Logos*, *Reason*; and *Arithmos*, *Numbers*) are a Series of Arithmetical Numbers, invented for the ease and expedition of Calculation by the Lord *Neper*, but greatly improved by Mr *Briggs*.

Logistical

Logistical Logarithms, are artificial Numbers deduced from the Logarithms of absolute Numbers, of which there are two sorts; one invented by *Jeremy Shakerly*, and the other by *Thomas Street*. The first I have continued to 1° 18′, and the latter to 120 Minutes, or 2 Hours, and there shewn the Construction of them both. *Shakerly*'s are made thus: To the Co. Ar. of the Logarithm of 3600 = Seconds in an Hour, add the Absolute Logarithm of any Number of Minutes reduced into Seconds, or any Minutes and Seconds jointly taken; the Sum is the Logistical Logarithm sought.

Example. What's the Logistical Logarithm of 1?

1 h.=3600″ Logar. 3.5563025	Co. Ar =	6.4436975
1′ = 60″ Logar. add		1.7781512
Logistical Logarithm of 1′ is		8.2218487

But we reject the two Figures to the right Hand. And these are Omitted in this Impression.

The Construction of Street's *Logistical Logarithms.*

To the Logarithin of 1°=60′, which is 3.5563 (omitting the three Places to the right Hand) add the Co. Ar. of the Minutes reduced into Seconds: The Sum is the Logistical Logarithm of any Minutes and Seconds under 60′.

Example. What's the Logistical Logarithm of 43′ 17″?

OPERATION.

1° = 60′ its Logarithm in Seconds 3.600″ =	3.5563
43′ 17′ = 2597″ Logar. Co. Ar. add	65855
Logist. Logar. of 43′ 17″ rejecting Radius is	.1418

For more than 60′, take the Co. Ar. of the Logar. of 1 h = 60 which is 3.55630, Co. Ar. 6.44369; and to this add the Logarithm of the Degrees, Minutes and Seconds all reduced into Seconds; this Sum is the Logistical Logarithm sought.

Example. What's the Logistical Logarithm of 81′ 50″?

OPERATION.

60′ = 3630″ Logar. Co. Ar. =	6.4437
81 50 = 4910″ Logar. add	3.6911
Logist. Logar. of 81′ 50″ is	1348

In

In this Edition these Logistical Logarithms supply the Place of *Shakerly*'s in all Cases.

L. L. signifies Logistical Logarithm.

Longitude in Astronomy, is the Distance of a Star or Planet counted in the Ecliptic from the beginning of *Aries*, according to the Order of the Signs, to the Place where the Star's Circle of Longitude crosses the Ecliptic; so that 'tis much the same as the Star's Place; and this may be either Heliocentric, or Geocentric; which see.

Longitude in Geography, is an Arch of the Equator, intercepted between the first Meridian and the Meridian of the Place; 'tis the difference either East or West between the Meridians of any two Places counted on the Equator.

Lucifer, the Morning-Star. *Venus* is so called when she is Oriental, and riseth before the Sun.

Lucida Coronæ, a fixed Star of the second Magnitude in the northen Garland, which see in the Catalogue of Stars.

Lucida Hydræ, a fixed Star.

Lucida Lyra, a fixed Star of the first Magnitude in the Constellation *Lyra*.

Luminaries, the Sun and Moon are so call'd by way of Eminence, for their extraordinary Lustre, and the great Light that they afford us.

Lunar Aspects, are those that the Moon makes with the other six Planets; as, when she comes in ☌, ⚹, □, △, or ☍, with them, then the Time is so marked in the *Ephemeris*.

Lunary Months, are periodical, synodical, or illuminative; which see under those Words.

Lunar Cycle. See *Cycle of the Moon*.

Lunations of the Moon, are the Times between one New Moon and another; and this is greater than the Periodical Month by two Days and five Hours; and is called the *Synodical Month*; but this Synodical Month is unequal in every Month in the Year: For in *December*, when the Earth is in *Perihelion*, the time between one Conjunction of the Sun and Moon, and the next, is more by about 12 Hours than it is in *June*, when the Earth is in *Aphelion*, which in the first Case is about 29 d. 19 h. and in the latter, 29 d. 7 h. the reason of which is very plain: For the Earth (or Sun apparently) moving faster in *December* than they do in *June*, of necessity there must be more Time spent for the Moon to come up to ☌ with the Sun in the former, than in the latter.

Luni-Solar Years, is a Period made by multiplying the Cycle of the Moon 19, by that of the Sun 28; the Product 532 Years,

Years, is the Space of Time in which the Holy Feast of *Easter* makes one perfect Revolution, and every thing depending thereon returns to the same again that they were 532 Years before.

Lupus, a southern Constellation, in form of a Wolf.

M

MAgnitudes; the Stars are divided into six several Sizes or Magnitudes for distinction sake; of which the greatest are called *Stars of the first Magnitude*; as *Sirius*, *Arcturus*, &c. the next to them in Brightness are called *Stars of the second Magnitude*; next Inferiours to them are called *Stars of the third Magnitude*; next to them are called *Stars of the fourth Magnitude*; the next less are of the fifth Magnitude; and the next less are of the sixth Magnitude. See the Catalogue.

Mars, is the Name of one of the Planets, which moves round the Sun in an Orbit between the Earth and *Jupiter*, and performs his Revolution in one Year 321 d. 23 h. 27′ 30″; his mean Diurnal Motion is 31′ 27″, his Orbit makes an Angle with the Ecliptic of 1° 52′, and he is 15 times less than our Earth; is of a red Colour like the Star *Aldebaran*, and is Retrograde once in two Years. He is called by the Poets *Aris*, *Pyrois*, *Mavors*, and *Gradivus*. See the System, and thus marked ♂.

Mathematical Horizon, is the same with true Horizon.

Mean Motion of a Planet, is, supposing it to move in a perfect Circle and equally every Day; divide 360° by the Number of Days in a Revolution, the Quotient will be the Mean Diurnal Motion; which see in the Tables of every Planet.

Mercury, the Name of one of the Planets, whose Orb is next the Sun; he performs his Revolution in 87 Days, 23 h, 15′ 53″, and his Mean Heliocentric Diurnal Motion is 4° 5′ 32″; his Orbit makes an Angle with the Ecliptic of 6° 54′; he is never elongated from the Sun more than 28° 21′ 8″, (see *Elongation*) and therefore seldom seen: He appears to us at the Earth Retrograde four or five times every Year, and is twenty seven times less than our Earth: This Planet is called by the Poets, *Archas*, *Cyllenius*, *Hermes*, and *Stilbone*; and thus charactered ☿.

Medium Cœli, is that Degree of the Ecliptic that is upon the Meridian at any time of Day or Night.

Meridian, from *Meridies*, Noon or Mid-day, is one of the six great Circles of the Sphere passing through both the Poles

of

of the World, and cutting the Horizon at right Angles, being equally distant between the East and West; unto which when the Sun or any Star come, it is the highest, or has then the greatest Altitude that it can have that Day in that Latitude. The Stars are then also said to Culminate or be South, when they are upon the Meridian.

Meridian Angle, is the Angle made by the Eclyptic and Meridian at any given Time of the Day or Night, which can never be more than 90 Degrees when ♋ or ♑ Culminate; nor less than 66 Degrees 31 Minutes, when ♈ and ♎ are on the Meridian. It is of great use in the Calculation of Solar Eclipses. See the Table for this purpose.

Meridional Southern, or towards the South. Some *Ephemeridists* distinguish the South Latitude of a Planet by an M.

Meridional Parts, are Tables now adapted for use in Navigation, in which the Meridians do encrease as the Parallels of Latitude decrease; for as the Parallels end in a Point in the Pole, so are the Meridians infinite long, being parallel to each other, never meet.

Metonic Year, invented by *Meton* the *Athenian*, is the Time of nineteen Years, the same with the Cycle of the Moon.

Micrometer, is an Instrument invented by our Countryman Mr *Townly*; which being fitted to a Telescope, is to take the Diameter of the Stars and Planets. See *Philos. Trans.* Numb. 25 and 29.

Milky-Way, *Via Lactea*, or *Galaxy*, is a white broad Path, or Tract encompassing the whole Heavens, and extending itself in the Sign of *Capricorn* from the Equinoctial to the Tropic of *Cancer*, with a double Path, and the rest of it is a single one. Some of the Ancients, as *Aristotle*, imagin'd that this Path consisted only of a certain Exhalation hanging in the Air, but by the Telescope-Observations of this Age it has been discovered to consist of an innumerable quantity of fixed Stars different in Situation and Magnitude; from the confused Mixture of whose Light its white Colour is supposed to be occasioned. This *Milky-way* begins at the Equinoctial at *Ophyus*, or *Serpentarius*, and passeth through the Constellations of *Aquila*, *Cygnus*, *Cassiopeia*, *Persus*, *Auriga*, part of *Orion*, part of *Scorpio*, *Sagittarius*, *Monoceros*, *Argo*, *Navis*, and the *Ara*. Its greatest Declination North is about 65 Degrees, and South 69 Degrees; it crosseth the Equinoctial from South to North in 5 Degrees of *Capricorn*, from North to South in 5 Degrees of *Cancer*. Its breadth where broadest, is about 25 Degrees near *Aquila*; but in other Places it doth not exceed 10 Degrees in breadth.

In the Months of *February* and *August* you have a full view of it in the Evenings.

Minute, is the 60th part of an Hour in Time, or of a Degree in Motion; so that every Hour, or Degree of any great Circle is divided into 60 Minutes, every Minute into 60 Seconds, and each Second into 60 Thirds.

Month properly speaking is the Time the Moon is in running through the Zodiac; and this she performs in 27 Days, 7 h. 43′ 7″. This is called the *Lunar* or *Periodical Month*; but the time between one Conjunction and another, with the Sun is called her *Sonydical Month*; this according to her middle Motion, she performs in 29 $\frac{1}{2}$ Days. There is also a Solar Month, which is the Time the Sun takes in running through one of the Signs in the Zodiac, which is about 30 $\frac{1}{2}$ Days, but not of an equal length; (see *Lunations*.) The Vulgar Computation of four Weeks, or 28 Days to the Month, agrees pretty near to the Moon's periodical Month mentioned above.

Moon, is one of the seven Planets, and the lowest of all in the System; she is an opake Body, borrows all her Light from the Sun, and respects our Earth for her Center; and not only the Moon itself, but also her whole System is carried round the Sun along with our Earth in a Year, (see *my Instrument made by* Thomas Heath *at the* Hercules *and* Globe *in the* Strand) This and her Vicinity to the Earth, is the cause of the great Difficulty we have in obtaining her true Place. Her Periodical Revolution, in reference to the fixed Stars, is 27 Days, 7 h. 43′, 7″; her Orbit intersects the Ecliptic in two opposite Points, called *Nodes*, making an Angle therewith of 4° 59′ 35″ in Conjunction, and in Opposition to the Sun; but in the Quadratures of 5° 17′ 20″; she is always eclipsed at the Full, and within less than 12 Degrees of her Nodes. For a farther account of all the Inequalities of this Irregular Planet, I shall refer my Reader to her *Theory* written by Sir *Isaac Newton*, which I have kept close too in compiling the following Tables of her Motions. She always appears to us at the Earth Direct, and is 50 $\frac{7}{11}$ times less than our Earth. Nothing is more common amongst the vulgar Country-People in the time of Harvest, than for them to talk of the Harvest-Moon; which, they suppose, is always at the Full at one and the same time in Harvest, and that she rises and sets several Days together at the same time; and that God gave her that Light and Stability at that time (above the rest of the Year) to ripen and bring forwards the Fruits of the Earth; but these are gross Absurdities, as I thus prove.

1. Because

1 Because she always moves direct according to the order of the Signs Eastward; and this Motion in Longitude, when slowest, can never be less than 11 Degrees in one Day, and this 11 Degrees in a right Sphere is 44 Minutes in Time; so that 'tis impossible she can rise or set two Days together at the same Time; and this Delay in her rising will be greatly increased when she is in *Perigeon*, or in a Sign of right or long Ascension with south Latitudes; I say, when these three Testimonies concur, there will be more than an Hour and a half difference between the time of her rising this Night, and the time of her rising the next Night to the Inhabitants of *England*.

2. But that the Moon doth rise in an oblique Sphere within 9 or 10 Min. two Nights together, is plain from this Demonstration; that is, when she happens in *Apogeon*, north Latitude, and in a Sign of oblique, or short Ascension.

3. It is also possible in the Month of *August* to the northern Inhabitants, that the Moon doth set two or more Nights together within less than 10 or 12 Min. of the Time each Night; and this is when she is in *Apogeon*, south Latitude, and in a Sign of oblique Descension.

Lastly, The great difference of the Moon's setting any two Nights together in an oblique Sphere, is caused by her being in *Perigeon*, having north Latitude, or in a Sign of right or long Descension. These three Testimonies concurring together, will cause her to set more than 1 ½ Hour later this Night, than she did the Night before. The Moon by the Poets is called *Cynthia*, *Diana*, *Latonæ*, *Lucina*, *Noctiluca*, *Phœbe*, *Proserpina*, and thus marked ☽.

Mora, is the continuance of the Moon within the Earth's Shadow; or the Time the Penumbra continues within the Earth's Disk.

Motion, is a continual and successive Mutation or Change of Place.

Motion, Sir *Isaace Newton*'s, three Laws of Motion.

1. That every Body will continue in its State, either of Rest or Motion, uniformly forward in a right Line, unless it be made to change that State by some Force impressed upon it.

2. That the change of Motion is proportionable to the moving Force impressed; and is always according to the Direction of that right Line in which that Motion is impressed.

3. That Re-action is always equal and contrary to Action; or, which is all one, the mutual Actions of two Bodies one upon another, are equal, and direct towards contrary Parts: As, when one Body presses and draws another, 'tis as much pressed, or drawn by that Body.

Mutual Aspects, are such as the Primary Planets make among themselves; as the ✱ of ♄ ♃, □ ♂ ☉, △ ♀ ☽, the ☍ ♃ ♀, &c.

Mythology, an expounding of Tables.

N.

NAdir, is the Point in the Heavens seemingly under the Earth, which is diametrically opposite to the Point directly over our Heads.

Nebulous Stars, seen thro' the Telescope, appear to be Clusters of small Stars, lesser than those of the sixth Magnitude.

Nocturnal Arch of the Sun, is that space in the Heaven, which he (apparently) runs thro' from the Time of his setting, to the Time of his rising; and this is always equal to the double of the Time of his rising; as when he riseth at four o'Clock in the Morning; that doubled, is eight Hours, the length of the Nocturnal Ark.

Nodes in Astronomy, are the Points or Intersections of the Orbs of the Planets with the Ecliptic; and in the Primary Planets these as well as the Aphelions, have a slow progressive Motion, as you may see in the following Tables of each Planet. For the Moon's Nodes, see *Dragon's Head* and *Tail*.

Nonagesimal Degree, is the 90th Degr. or highest Point of the Ecliptic at any given Time of the Day or Night; and its Altitude is always equal to the Angle that the Ecliptic makes with the Horizon. Which is also equal to the Distance between the Pole of the Ecliptic, and Vertex, or Zenith of the Place. It is of great use in the Calculation of Solar Eclipses.

Northern Signs of the Ecliptic or Zodiac, are those six which constitute that Semicircle of the Ecliptic which inclines to the northward from the Equinoctial, as *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*.

Nucleus in an Astronomical Sense, is by *Hevelius*, and others, used for the Head of a Comet, and by others for the Central parts of the Planets.

Number of Direction, is a Number not exceeding 35; which Number is the Boundary, or Limit of *Easter-Day*, which always falls between *March* 21, and *April* 25, exclusive, being 35 Days. This Number changes every Year, but not in a due order; but it may be found arithmetically thus:

1. From 26, subtract the Epact for the Year proposed; but when the Epact is 28 or 29, then subtract it from 56, and reserve the Remainder.

2. Divide the Epact by 7; its Remainder subtract from 8; this Remainder sub. from the Dominical Letter, numbering them thus, A1, B2, C3, D4, E5, F6, G7; what remains now, add to the first reserved Number, which gives the *Number of Direction* for the Year proposed. *Note*, When you cannot subtract from the Number of the latter, borrow 7; and if nothing remains, it must be called 7; and when the Epact is 28, add 2 to the Remainder of the Sub. from 8; and when the Epact is 29, you must subtract 5 from the Remainder of the Sub. from 8; the Sum or Difference will be the true reserv'd Number; and in Leap-Year you must take the Letter that serves from *February* to the Year's end.

Example. What's the Number of Direction for the Year of Christ 1736?

Epact 28, Dominical Letters D C = 3. Then 56—28=28 and 28÷7 Remains 0=7.8—7=1 +2=3—3=0 and 28 +7=35 the *Number of Direction* sought. But by the Tables in the *Doctrine of the Sphere* you have it without any manner of trouble.

Nychthemeron, the length of the Natural Day in the Planets.

O.

OBlique *Ascension*, is that Degree and Minute of the Equinoctial, which rises with the Center of the Sun, and Moon, or Star, in an oblique Sphere.

Oblique Descension, is that part of the Equinoctial which sets with the Center of the Sun, Moon, or Star, or with any Point of the Heavens in an oblique Sphere.

Obquility

Obquility of the Ecliptic, is the Angle that the Ecliptic makes with the Equinoctial, which is at *Aries* and *Libra*, where it intersects it, and is 23 Degr. 29 Min. equal to the Sun's greatest Declination.

Oblique Signs, are such as ascend obliquely; those are ♑, ♒, ♓, ♈, ♉, ♊; and they will descend rightly: Their opposite ♋, ♌, ♍, ♎, ♏, ♐, do ascend right, and descend obliquely to the northern Inhabitants.

Oblique Sphere, is where either Pole is elevated any Number of Degrees less than 90, and consequently the Axis of the World, the Equinoctial and Parallels of Declination will cut the Horizon obliquely, from whence comes the Name.

Occident, is the western part of the Horizon, or 'tis that part where the Ecliptic or Sun therein descends into the lower Hemisphere.

Occident Estival, is that Point of the Horizon where the Sun sets at his entrance into the Sign *Cancer* when the Days are the longest to all the northern Inhabitants.

Occident Equinoctial, is that Point of the Horizon where the Sun sets when he enters *Aries* or *Libra*.

Occident Hybernal, is that Point of the Horizon where the Sun sets when he enters into *Capricorn*; at which time the Days with us are shortest.

Occidental, (i. e. Westerly.) In Astronomy, a Planet is said to be Occident when it sets after the Sun; and in *Ephemerides*, on the top Columns of *Lunar* Aspects, you find *Occi.* Which signifies Occidental, and which shews that Planet to be an Evening-Star.

Occultation in Astronomy, is the Time that a Star or Planet is hid from our Sight when eclipsed by the Interposition of the Body of the Moon, or some other Planet between it and us.

Octant or Octile, in Astronomy, signifies a Planet, &c. being in such an Aspect or Position to another, that their places differ the eighth Part of the Zodiac, or 45 Degr.

Olor, or *Cygnus*, the Swan, a Constellation in the northern Hemisphere. See the *Catalogue of fixed Stars*.

Ophiucus, one of the northern Constellations, the same with *Serpentarius*.

Opposition, is that Position or Aspect of the Stars or Planets, when they are six Signs, or 180 Deg. distant from one another, and is marked thus ☍.

Orb, is any hollow Sphere; but the Orbs of the Planets are those Circles (or rather *Ellipses*) in which they move, and the Ecliptic

Ecliptic is called the *Sun's* or *Earth's Orbit*: They are not at all in the same Plain with the Ecliptic; but variously inclined to it, and to one another at different Angles; the Plain of the Ecliptic intersects the Plain of every Planet's Orbit in two opposite Points, call'd *Nodes*; the Places of which and the Inclinations may be seen in the Tables of each Planet.

Orbis Magnus, is the Orbit of the Earth in its Annual Revolution round the Sun. This, in respect to the vast distance of the fixed Stars, is no more than a Point.

Orient, is the East Part of the Horizon; or, it is that part of the Horizon where the Ecliptic, or the Sun therein ascends into the upper Hemisphere.

Orient Estival, is that Point of the Horizon wherein the Sun rises when he enters *Cancer*.

Orient Equinoctial, is that Point of the Horizon where the Sun rises when he enters *Aries* and *Libra*, making the Days and Nights equal.

Orient Hybernal, is that Point of the Horizon where the Sun rises when he enters *Capricorn*.

Oriental in Astronomy, a Planet is said to be Oriental when he rises in the Morning before the Sun; so in an *Ephemeris* you will meet with *Orion* the Head of the *Lunar* Aspects, which tells you, that that Planet is then Oriental of the Sun, or a Morning-Star.

Orion, a southern Constellation.

Orthographic, Projection of the Sphere, is the drawing the Superficies of the Sphere on a Plane, which cuts it in the middle, the Eye being placed at an infinite distance vertically to one of the Hemispheres; in which all the Hour-Circles become Ellipses. 'Tis the same with *Analemma*; which see.

P.

PAnselene, signifies the Full Moon.

Paracentric Motion, is when a Planet approaches nearer to, or recedes farther from the Sun or Center of Attraction.

Parallax, is that Arch of a great Circle passing through the Zenith and true Place of the Sun, Moon or Star, and intercepted between the true and apparent Place: Because the true Place is supposed to be beheld from the Earth's Center; but the Apparent from the Superficies; and that difference is the Angle of

of Parallax; of which there are five sorts, *viz.* in R. Asc. Declination, Altitude, Longitude, and Latitude: For the understanding of which observe these following Consectaries.

CONSECTARY 1.

If the distance of the Moon from the Point ascending or Point descending be less than her Altitude, she has then no Parallax of Latitude; but this can never happen, but in such Latitudes where the Moon's Orb, or Ecliptic become Vertical Circles.

2. If the Distance of the Moon from the Point ascending or descending be just 90 Deg. then doth a vertical Circle intersect the Ecliptic at right Angles, and there is then no Parallax of Longitude, but only of Latitude.

3. If the Vertical Circle passing thro' the Moon's Center, fall upon the Ecliptic at oblique Angles, then there is Parallax both in Longitude and Latitude.

4. All places on the Earth that have more than 28° 46′ 20″ of North Latitude, to them the Moon's Parallax is South, and she is depressed below her true Place, according as she is East or West of the Nonagesime Degree. These Parallaxes are of singular use in the Calculation of solar Eclipses, &c.

Parallactic Angle. See *Angle.*

Parallax of the Annual Orbit, is what the Earth would appear to be elongated from the Sun to an Eye at the Planet, which in the Primary Planets are these in their Orbits.

	Greatest Angle.		Least Angle.	
	°	′	°	′
Saturn	6	27	5	34
Jupiter	11	37	10	13
Mars	36	21	30	33
Venus	36	32	35	14
Mercury	25	24	16	49

But when the Logarithm of their Distance from the Sun is curtailed, it will make a small Difference in the Ecliptic from what is here set down. See my *Uranoscopia.*

Paraselene,

Paraselene, a Mock-Moon.

Parhelion, a Mock-Sun.

Pascha, Easter-Day.

Path of the Vertex, is a Circle described by any Point of the Earth's Surface, as it turns round on its Axis. This Point is considered as vertical to the Earth's Center, and is the same with what is called *Vertex*, or the *Zenith*. The Semidiameter of this Path of the *Vertex* is always equal to the Complement of the Latitude to the Point or Place that describes it.

Pegasus, a Constellation in the northern Hemisphere.

Penumbra in Astronomy, is a faint kind of Shadow, or the utmost Edge of the perfect Shadow which happens at the Eclipse of the Moon; so that it is very difficult to determine where the Shadow begins, and where the Light ends; as I have often proved by my *Observation of Eclipses*.

Penumbra in the New Astronomy; its Semidiameter is equal to the Sum of the apparent Semidiameters of the Sun and Moon: For if at the time of the true Conjunction of the Sun and Moon, none of the *Penumbra* fall within the Earth's Disk, the Sun will then no where on the Earth be Eclipsed.

Periæci, are those Inhabitants of the Earth who live under the same Parallels, but under opposite Semicircles of the Meridian, when they have the same Seasons of the Year, *viz.* Spring, Summer, Autumn, and Winter, at the very same time; as also the same length of Days and Nights; for 'tis in the same Climate, and at an equal distance from the Equator: But when 'tis Noon to the one, 'tis Midnight to the other.

Perigeon, or *Perigæum*, is a Point in the Heavens wherein a Planet is at its nearest distance from the Earth. When the mean Anomaly of the Moon is six Signs, she is then in *Perigeon*, and her Diurnal Motion is about 15 Deg. This Point is always diametrically opposite to the *Apogeon*, extended by the Transverse Diameter of her Elliptical Orbit.

Perihelion, is the Point in the Heavens where the Earth or any of the Primary Planets are nearest to the Sun: Their Heliocentric Motions are now the swiftest, and their mean Anomalies are six Signs. This Point is diametrically opposite to the *Aphelion*.

Period of the Eclipses. See *Saros*.

Periodical Month, is the Space of Time the Moon finishes her Revolution in.

Periscii, are the Inhabitants of the Frozen Zones; for as the Sun goes round them for six Months, so doth their Shadows; whence the Name.

Perseus, a Constellation in the northern Hemisphere.

Phases in Astronomy, is used for the several Appearances of the Planets, especially the *Moon* and *Venus*, who seem to our sight, obscure, horned, half illuminated or full of Light; and by the Telescope the same is observed in *Mars*.

Phœnix, a southern Constellation.

Phænomena, are Appearances in the Heavens.

Phænomenon, any single Appearance in the Heavens, as of an Eclipse, Comet, &c.

Phosphorus, the Bringer of Light; it is the Name of *Venus* when she is the Morning-Star.

Phrocyon, a fixed Star of the second Magnitude in the Constellation *Canis minor*, whose Longitude Anno 1742 is ♋ 22° 13' 40'', Latitude 15° 57' 55'' South.

Pisces, the Name of two Constellations, the one in the Zodiac marked thus ♓, unto which the Earth comes about the 12th of *August*; the other in the southern Hemisphere.

Place of the Sun or Star, it is the same with Longitude of the Sun, Moon, or Star; which see.

Place, (true) of a Planet, is that which is pointed at by a Line drawn from the Earth's Center to the Star.

Place, (apparent) is that which is beheld by the Observer from the Earth's Superficies.

Planets, are the seven Erratic Stars, *Saturn* ♄, *Jupiter* ♃, *Mars* ♂, *Earth* ⊖, *Venus* ♀, *Mercury* ☿, *Moon* ☽; which see under those Words. The Sun being now exempted from being one of that number.

Plato's System, he was a divine *Athenian* Philosopher, flourished 420 Years before Christ. He fixed the Earth in the Center of the World; next to the Earth, the Air, and then the Region of Fire; above that the Moon; next above the Moon, he placed the Sun, making his Annual Motion round the Earth. Next above the Sun in his System is *Mercury*, then *Venus*, then *Mars*, then *Jupiter*, and the highest of all he placed *Saturn*; and above all the Planets he placed the fixed Stars.

Not much differing from this System, was that of *Porphyrius*, who flourished 325 Years before Christ: He differed from the *Platonic* System only in the Situation of *Venus* and *Mercury*, viz. he placed *Mercury* in an Orb next above *Venus*; both of which *Systems* are ridiculous and absurd, and are therefore exploded.

Pleiades, the seven Stars; which see in the Catalogue.

Poetical Rising and *Setting* of the Stars, are of three sorts, viz. *Achronical*, *Cosmical*, and *Heliacal*; which see.

Point

Point of Station in Aſtronomy, are thoſe Degrees in the Zodiac in which a Planet ſeems to ſtand ſtill; which always happens juſt before and after their Retrogation.

Polar Circles, are two leſſer Circles of the Sphere, parallel to the Equinoctial, and 23 Deg. 29 Min. diſtant from the Poles of the World: That about the North Pole is called the *Artic Circle*; and that about the South Pole, the *Antartic Circle*.

Pole-Star, is a Star of the ſecond Magnitude, in the Tail of the *Little Bear*; the height of it above the Horizon is nearly equal to the Latitude of the Place: For a further Account of it, ſee my *Syſtem of the Planets demonſtrated*.

Poles of the World, are two Points in the Axis of the Equator, each 90 Deg. diſtance from its Plain; one pointing to the North, which is therefore called the *North* or *Artic Pole*; and the other Southward, which therefore is called the *South*, or *Antartic Pole*.

Poles of the Ecliptic, are two Points in the Solſtitial Colure 23° 29' diſtant from the Poles of the World, lying exactly in the Polar Circles; ſo that when the Sign *Capricorn* is on the Meridian above the Earth, the North Pole of the Ecliptic is on the Meridian above the North Pole of the World; but when *Cancer* is on the Meridian above the Horizon, then the ſaid Pole of the Ecliptic is on the Meridian under the Pole of the World. The Axis of the Sun and Moon do nearly point to the Poles of the Ecliptic.

Pollux, a fixed Star, ſee the Catalogue.

Poſtulata, is a grantable Requeſt, or ſuch a Demand as reaſonably cannot be denied.

Primary Planets, are *Saturn*, *Jupiter*, *Mars*, *Venus*, and *Mercury*.

Prime of the Moon, ſignifies the New Moon at her firſt appearing.

Primum Mobile, the firſt Mover, according to the *Ptolemaic* Aſtronomy, is ſuppoſed to be a vaſt Sphere, whoſe Center is that of the Earth; this, they ſuppoſed turned round in 24 Hours; but it is now found to be falſe, and the whole Hypotheſis is exploded.

Proceſſion of the Equinoxes; in the New Aſtronomy, the fixed Stars are ſuppoſed to be immoveable; and that the Earth travels round the Sun by its Annual Motion; ſo that its Axis makes always an Angle of 66 Deg. 31 Min. with the Plane of its Orbit; and by the Earth's Diurnal Motion once round its Axis in 24 Hours to the Eaſt, the Equinoctial Points are moved the contrary way about 50 Seconds a Year; and for this reaſon

the fixed Stars ſeem to be carried forward according to the order of the Sign, about as much in the ſame Time.

Projection of the Sphere in Plano, is a true Geometrical Delineation of the Circles of the Sphere, or any aſſign'd part of them upon the Plain of ſome one Great Circle, as on the Horizon, Meridian, Equinoctial, Ecliptic, Colures, or on the Tropics, &c. and this is either Stereographic, which ſuppoſes the Eye to be but 90 Degr. diſtant from, and perpendicular to the Plane of the Projection; or Orthographic, when the Eye is at an infinite diſtance, in the Center of the Projection.

Prometheus, or *Hercules*, the Name of a northern Conſtellation; it is called alſo *Engonaſis*.

Problem, is when ſomething is propoſed to be done.

Proportion. When two Quantities are compared one with another, in reſpect of their greatneſs or ſmallneſs, that Compariſon is called *Ratio*, *Reaſon*, *Rate*, or *Proportion*: But when more than two Quantities are compared, then the Compariſon is more uſually called, The Proportion that they have to one another. The Words *Ratio* and *Proportion* are frequently uſed promiſcuouſly.

1. To two Numbers given to find a third Proportional; as, ſuppoſe 3 and 6, then $\frac{6\times6}{3}=\frac{36}{3}=12$, is the third Proportional required.

2. To three Numbers given to find a fourth Proportional; as, ſuppoſe 3, 6 and 8; then $\left(\frac{6\times8}{3}=\frac{48}{3}=\right)16$, is the fourth Proportional required.

3. To two Numbers given to find a third, fourth, fifth, ſixth, &c. Number in a continual Proportion, to the two given Numbers; as, ſuppoſe 2 and 4, $\left(\frac{4\times4}{2}=\right)8$; $\left(\frac{8\times8}{4}=\right)16$; $\left(\frac{16\times16}{8}=\right)32$; $\left(\frac{32\times32}{16}=\right)64$; ſo I find the ſix Numbers in a continual Proportional are 2, 4, 8, 16, 32, 64; and ſo on *ad infinitum*.

4. Between two Numbers given to find a mean Arithmetical Proportion; as ſuppoſe 10 and 20: Thus $\frac{10\times20}{2}=\frac{30}{2}=15$ the Anſwer.

5. Between two Numbers given to find a Geometrical Mean Proportion; as suppose 4 and 9: Then $4 \times 9 = 36$; and $\sqrt{36} = 6$, the Answer.

6. Between two Numbers given to find a Mean Musical Proportion:

Rule. Multiply the Difference of the Terms by the lesser Term, and also add them together: This done, divide the Product by the Sum of the Terms; and to the Quotient add the lesser Term: This Sum is the Musical Mean desired.

Example. Let 9 and 18 be given; I demand the Musical Mean Proportional.

Operation. $18 - 9 = 9$; $9 \times 9 = 81$; $18 \times 9 = 27$, and $\frac{81}{27} = 3$, then $3 + 9 = 12$, the Musical Mean sought. This Musical Proportion is of excellent use in Philosophical Experiments of Colours: For if you take several Colours and put them on a Wheel, and distant one from another in this Proportion; turn the Wheel fast round, and they will all appear white.

Subduplicate Proportion, is when any Number is contained in another twice, thus, 3 is Subduple of 6, that is 6 is double of 3, *&c.*

Propositions, is used promiscuously, (i. e.) either for a Theorem or a Problem.

Prostapheresis in Astronomy, is the same with Equation of the Planets Orbit, and is the Difference between the mean and true Place. See the Tables.

Pseudostella in Astronomy, signifies any kind of Comet or Phænomenon newly appearing in the Heavens like a Star.

Ptolemy. Claudius Ptolemæus, was a Native of *Pelusium*, a City of *Africa* in the Kingdom of *Egypt*. He flourished 135 Years after Christ, and is said to be the Author of a System now known by that Name; in which he fixed the terraqueous Globe in the Center of the World, and about it the elementary Regions; next above that the *Moon*; then *Mercury*; next above him *Venus*; and then the Sun moving in the middle of the Planetary System; next above the Sun is the Orb of *Mars*, then *Jupiter*, and next above *Jupiter*, *Saturn*; and above these the fixed Stars; the System being made up of solid Orbs and Epicycles, and other ridiculous Stuff to solve the Phenomema; but Telescope Observations have exploded this System.

Ptolemaic System, supposes the Earth fixed in the Center, and all the Heavenly Bodies moving round: But this is false, as I have

have proved in my *Astronomy*, or *System of the Planets Demonstrated.*

Pythagorean System, is the same with the *Copernican* System, which supposes the Sun fixed in the Center of the World, and all the Planets moving round: This is what we embrace, and have demonstrated in the fore-cited Book.

Q.

QUadragesima, is the first *Sunday* in *Lent*, and so called, because 'tis about the 40th Day before *Easter*, and on the like account the three preceeding *Sundays* are called *Quinquagesima*, *Sexagesima*, and *Septuagesima*.

Quadrant, is the Quarter, or fourth part of a Circle, graduated on the Limb with 90 Degrees; its Furniture are *Telescope* and *Micrometer*, to take the Altitudes and Diameters of the Planets and Stars; and such a one there is now at the *Royal Observatory* at *Greenwich-Hill*, of near eight Foot *Radius*. It is an Instrument of exquisite Workmanship; and being now under the Care of that skilful Astronomer Dr *Edmund Halley*, it is fixed upon a strong Mural Arch, and exactly on the Meridian, to take the Meridian Altitude of the Moon and other Planets as they pass by.

Quadratures, or Quarters of the Moon, are the middle Points of her Orbit between the Conjunction and Opposition; and they are so called, because a Line drawn from the Earth to the Moon, is then at right Angles with a Line drawn from the Earth to the Sun; the Luminaries are then a Quarter of the Zodiac or 90 Degrees distant from each other, equal to three Signs, and in an *Ephemeris* is thus character'd □.

Quarters of the Year, are four in Number; the first begins when the Sun apparently enters the Equinoctial Sign *Aries*, making the Days and Nights equal all the World over, except under the Poles, and continues while the Sun is runing through ♈, ♉, ♊. This is called the Spring-Quarter. The Summer-Quarter begins about the 10th Day of *June*, and continues while the Sun runs through ♋, ♌, ♍, making the longest Days to all the Northern Inhabitants. The third is called the *Autumn*, or Harvest-Quarter, and begins about the 12th Day of *September*, continues while the Sun is running through ♎, ♏, ♐, the Days and Nights are again equal. The fourth and last is called the Winter-Quarter, making then shortest Days and longest Nights to all the Inhabitants on this side the Equator. This Quarter continues all the time the Sun is passing through ♑, ♒, ♓.

Quartile,

Quartile, the same with Quadrature, which see.

Quincunx, is one of *Kepler*'s new Aspects of the Planets, and is when they are distant from each other 5 Signs or 150 Degr. marked thus, *VC* or *Q*.

Quindecile, in one of *Kepler*'s new Aspects marked thus *Q. d.* and happens when Planets are 24 Degr. distant from each other.

Quinquagesima. See *Quadragesima*.

Quintile, is one of *Kepler*'s new Aspects marked thus *Q*; and is when Planets are 2S. 12° assunder.

R.

RAdius, is the whole Sine or Semidiameter of any Circle.

Rational, real or true Horizon. See *Horizon*.

Rays, or Beams of the Sun, Rays of Light, are either according to the Atomical Hypothesis, those very minute Particles or Corpuscles of Matter, which continually issuing out of the Sun, do thrust on one another all round in Physically short Lines; or else, as the *Cartesians* assert, they are made by the Action of the Luminaries on the contiguous *Æther* and Air, and so are propagated every way in streight Lines through the Pores of the *Medium*.

Rays, Convergent, are those which going from divers Points of the Object, incline towards one and the same Point tending to the Eye.

Rays, Divergent, are those which going from a Point of the visible Object, are dispersed and continually depart one from another, according as they are removed from the Object.

Reciprocal Proportions, are when in four Numbers the fourth has the same Proportion to the third, as the first has to the second, and *vice versa*: Thus, in two equal Rectangles, A and B, whose length are 6 and 3, breadth 2 and 4 Yards, respectively; where $6 : 3 :: \frac{1}{2} : \frac{1}{4}$, that is, the Lengths are as the Reciprocals of the Breadth, or the Lengths are said to be Reciprocally as the Breadth: On which is founded the *Indirect*, or *Inverse Rule of Three*.

Recession of the Equinox, is the going back of the Equinoctial Points every Year about 50″. The Reason of which is the Earth's being thrown into a Spheroidical Figure by its Diurnal Motion.

Reduction in Astronomy, is the Angle that is made between the Axis of the Ecliptic, and the Axis of the Planets Orbit, which is equal to the Quantity of the Ecliptic intercepted between the two Axis.

Reflection

Reflection in the new Astronomy, is the distance of the Pole from the Horizon of the Disk; which is the same thing as the Sun's Declination.

Refraction Astronomical, is that which the Atmosphere produceth, whereby a Star appears more Elevated above the Horizon than really it is.

Refraction Horizontal, is that which causes the Sun and Moon to appear on the Edge of the Horizon, when they are as yet somewhat below it. In the following Astronomical Tables I have inserted Mr *Flamsteed*'s Tables of Refractions: But this is varied by the Weather; and in places more northerly than *London* it has been much greater than has been asserted by Mr *Flamsteed:* For in the Year 1695, a Town called *Pello*, in the Latitude of 65° 53′, ten Miles to the northward of *Tornea* in the western *Bothnia*, on the 14th of *June*, at 12 Hours P. M. when the Center of the Sun was depressed 40 Min. below the Horizon, he was seen by the means of the Refraction at the Altitude of two Diameters, *Hodgson*, Vol. II. Page 274. And the known Experiment of putting a Shilling into a Bowl of clear Water, doth very well explain the nature of Refractions: But that this may be understood by every one that would be an Astronomer, I shall explain its Laws; which are these: A Ray of Light passing out of a fine into a more dense *Medium*, is Refracted downwards to the Perpendicular L G; but passing out of a denser into a finer *Medium*, the Rays of Light will be Refracted from the Perpendicular; so E D will be turn'd out of its streight Course to D A: For if the Refraction be made out of Air into Water, then the Sine of the Incidence is to the Sine of Refraction as 4 to 3; if out of Air into Glass, the Sines are as 17 to 11, *& vice versa*. A Ray of Light passing from A to D, will not go streight on to M, but will be turned out of its way to E: Make the Angle C D L of Reflection = to the Angle A D L of Incidence, and draw the Chord A C; then is A B the Sine of the Angle of Incidence, and B C the Sine of Reflection: Make A B = 4, and B F = 3; draw F E, and D E, so is H D E the Angle of Refraction, and H E the Sine thereof.

I K

thereof. The Rays of Light passing through Oil of Turpentine and through Water, the Proportion is as 25 to about $16\frac{1}{2}$, which proves Oil is denser than Water.

Regel, or *Regil*, is a fixed Star of the first Magnitude in *Orion*'s left Foot; its Longitude *Anno* 1742, is ♊ 13° 13′ 40″. Latitude 31° 10′ 11″ South.

Region, Ætherial in Cosmography, is the vast Extent of the Universe; wherein are comprized all the Heavens and Celestial Bodies.

Retrograde in Astronomy, is only appropriated to the five Primary Planets, when by their proper Motion in the Zodiac they seem to move backward, or contrary to the Succession of Signs, as *Saturn* did this present Year 1742, go back from 22° 17′ ♌, to 15° 17′, that is 7°, and *Venus* from 20° 22′ ♈, to 4° ♏, that is, 16° 22′ Retrograde; but this Motion is not real in the Heliocentric, but only in the Geocentric Motion, occasioned by the Annual Motion of the Earth, as I have proved by the Instrument in my *System of the Planets demonstrated.*

Retrocession, the same with *Recession*, which see.

Revolution in Astronomy, is the Circumvolution of any Cœlestial Body, till it returns to the same Point in which it was when it first began. The Time of the Revolutions of each Planet you may see under their Names.

Right Ascension of the Sun or Star, is that Degree of the Equinoctial accounted from the beginning of *Aries*, which rises with it in a right Sphere; or it is that Degree and Minute of the Equinoctial (counted as before) which comes to the Meridian with the Sun, Moon, or Stars, or with any part of the Heavens in an Oblique Sphere. The reason of which referring it to the Meridian, is because that is always at Right Angles to the Equinoctial, which the Horizon only is in a Right Sphere.

Right Signs, are *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, and *Sagittary*. They are called *Signs of Right Ascension*; because in an Oblique Sphere that part of the Ecliptic they pass, nearly cuts the Eastern Horizon as they rise at right Angles.

Rising of the Sun, Moon, or Stars, is their appearing above the Eastern Horizon.

Ring of Saturn, is an opacous, solid, circular Arch and Plane, like the Horizon of a Globe, of Matter compassing entirely round the Planet, and no where touching: Its Plane is at this Time nearly parallel to the Plane of our Earth's Equator; the Diameter of this Ring is $2\frac{1}{4}$ of *Saturn*'s Diameters; and the Distance of the Ring from the Planet, is about

the Breadth of the Ring it ſelf. See *Hugens* his *Syſtema Saturniana*, 1659. In one Revolution of *Saturn*, this Ring is twice very open, *viz.* when ♄ is in ♊ and ♐, and twice quite ſhut, *viz.* when ♄ is in ♍ and ♓.

Roman Indiction. See *Cycle*.

S.

SAgittarius, is the ninth compleat Sign of the Zodiac; but in Calculations, Number 8, and character'd thus ♐. The Earth enters this Sign about the 10th Day of *May*.

Saros, is a Period for Eclipſes, and called both by Mr *Flamſteed*, and Dr *Halley*, the *Chaldean Saros*; it contains in Leap-Year 18 Years, 11 Days, 7 Hours, $43'\ 15''$; in a common Year 18 y. 10 d. 7 h. $43'\ 15''$: The mean Motion of the Sun and Moon in 18 y. 11 d. 7 h. $43'\ 15''$ are equally $0^s\ 10^\circ\ 48'\ 6''$; of the Moon's *Apogeon* $0^s\ 13^\circ\ 39'\ 34''$; of her Retrograde Node $11^s\ 18^\circ\ 43'\ 38''$, and of the Moon from the Sun, nothing. This in the 74th Page of my *Syſtem of the Planets demonſtrated* I call *Mr* Whiſton's *Period*; but Dr *Halley* aſſured me, that that Gentleman had it from himſelf, and deſired me to let the World know ſo much. This Period may ſerve very well for common uſe to examine Eclipſes by; but not to truſt to for the preciſe time: Therefore I refer you to the following Precepts; where you have the exact methods of omputing them.

Satellites, by Aſtronomers are taken for thoſe Planets who are continually waiting upon, or revolving about other Planets; as the Moon may be called the *Satellite of the Earth*; and the reſt of the Planets *Satellites of the Sun*; but the Word is chiefly uſed for the new-diſcovered ſmall Planets, which make their Revolution about *Saturn* and *Jupiter*; of which there are five about *Saturn*, and four about *Jupiter*, which were firſt diſcovered by *Galilæus*.

Saturn is one of the Primary Planets, and the higeſt of all in the Planetary Syſtem: He performs his Revolution round the Sun in 29 Years, 174 Days, 6 Hours, $36'\ 26''$. For his other Motions ſee the following Tables: He is Retrograde once every Year. And is called *Chronus*, *Falcifer*, *Phænon*, and Marked thus ♄.

Scenographic Projection, is what is commonly called *Perſpective*.

Scholium,

Scholium, is a short Critical Exposition, gained from a former Demonstration, or a Corollary wanting an Explication.

Scorpio, is the eighth Sign in the Zodiac, marked thus ♏; but in Calculation, Number 7. Unto this Sign the Earth comes about the 9th Day of *April.*

Season of the Year. See *Quarters of the Year.*

Secondary Planets, are such as move round others, whom they respect as the Center of their Motion, though they move also along with the Primary Planets in the Annual Orbit round the Sun; and these are the Moon and the Satellites of *Saturn* and *Jupiter.*

Second, the Sixtieth part of a Minute, either of Time or Motion.

Secondary Circles, are all Circles which intersect one of the six great Circles of the Sphere at Right Angles; such are the *Circles of Longitude*, cutting the Ecliptic at right Angles; also the *Azimuths*, or *Vertical Circles* in respect of the Horizon.

Semita Luminoso, is a Name given by Mr *Childrey* in his *Britannica Baconica*, Pages 183, 184, to a kind of lucid Tract in the Heavens, which a little before the Vernal Equinox (he saith) may be seen about 6 o'Clock at Night, extending from the Western Edge of the Horizon up towards the Pleiades. *Cassini* and *Fatio*, saith it may be seen about the latter end of *February*, and the beginning of *October.*

Semiquadrate, is one of *Kepler*'s new Aspects, marked thus *S. q.* and is when two Planets are distant from each other 1 S. 15°. Octile, or Sesq. Quadrate.

Semisextile, is one of *Kepler*'s new Aspects, and marked thus *SS*; it is made by two Planets of the distance of one Sign from each other.

Semiquintile, is when Planets are distant from one another 36°, marked thus, *Dec. Decile.*

Sensible Horizon. See *Horizon.*

Septuagesima Sunday. See *Quadragesima.*

Septentrional, northern.

Sequitertianal Proportion, is when any Number or Quantity contains another once and one third.

Serpens, a northern Constellation, called *the Serpent of* Ophiuchus.

Serpentarius, or *Ophiuchus*, the Serpent-bearer a northern Constellation.

Sesquialteral Proportion, is when any Number or Quantity contains another once and an half, and the Number so contained in the greater, is said to be to it in Subsesquialteral Proportion.

Sesquiquintile,

Sesquiquintile, is an Aspect of the Planets when $3^{S}\ 18^{\circ}$ distant from each other.

Sesquiquadrate, is a new Aspect of 4 S. 15°, marked thus *Ss. q.*

Setting of the Heavenly Bodies, is when they go down in the western Horizon. This is either true, or apparent: In the following *Doctrine of the Sphere* I have shewn how to calculate both for any Time and Place.

Sexagenary Tables, were Table contrived formerly for finding the part Proportional of an Hour, Degree, *&c.* but now they are quite out of Doors as being better supplied by the Logistical Logarithms.

Sextile, is an Aspect of the Planets, when they are distant two Signs, 60 Deg. being a sixth Part of the Zodiac, and marked thus ⚹.

Siderial Year, is the Space of Time the Earth is going round the 12 Signs of the Zodiac in respect of the fixed Stars, which is 365 D. 6 H. $9^{I}\ 24^{II}\ 27^{III}$.

Signs, are the 12 Signs of the Zodiac, *Aries* ♈, *Taurus* ♉, *Gemini* ♊, *Cancer* ♋, *Leo* ♌, *Virgo* ♍, *Libra* ♎, *Scorpio* ♏, *Sagittary* ♐, *Capricorn* ♑, *Aquarius* ♒, *Pisces* ♓.

Sinister Aspect, is made according to the order of the Signs from *Aries* to *Taurus*, &c.

Sirius, one of the brightest fixed Stars in the Heavens.

Slow in Motion: The Planets are always slow in Motion when their Anomalies are 0 Signs.

Solar Year, is either Tropical or Siderial; which see under these Words.

Solstice, is the Time when the Sun (apparently) enters the Tropical Points *Cancer* and *Capricorn*; is got farthest from the Equinoctial, and before he returns back towards it, seeming to be for some Time at a stand, *viz.* that part of the Ecliptic before and after the Tropical Points, lies near parallel to the Equinoctial, and consequently while the Sun moves through these 10 Deg. of the Ecliptic, his Declination is insensibly altered. The Summer-Solstice is called *Estival*; and the Winter *Hyemal*.

Solstitial and Equinoctial Colures, are two great Circles of the Sphere, meeting in the Poles of the World, and cutting each other at right Angles, passing through the four Cardinal Points: That which passeth through *Aries* and *Libra*, is called the *Equinoctial Colure*; and that which passeth through *Cancer* and *Capricorn*, the *Solstitial Colure*.

Sound,

Sound, seems to be produced by the subtiler and more etherial Parts of the Air, being formed and modified into a great many small Masses or Contextures, exactly similar in the Figure, which Contectures are made, by the Collision and peculiar Motion of the Sonorous Body, and flying off from it, are diffused all round in the Medium, and there do affect the *Organ* of the Ear in one and the same manner. Sir *Isaac Newton* found by a very nice Experiment that Sound moves 968 Feet in a second of Time.

Southing of the Stars, is the same with the time of their culminating, or being upon the Meridian; for then they are just got half way of their Journey betwixt their rising and setting.

Southern Signs. See *Austral*.

Spheric Geometry, or Projection, is the Art of describing on a Plain the Circles of the Sphere, or any part of them, in their just Position and Proportion; and of measuring their Arks and Angles when projected. The Circles of the Sphere, as to their Projection on any Plane, are of four kinds.

1. The *Primitive Circle*, or Limb which bounds the Projection, and with which 'tis always made.

2. A *Direct Circle*, whose Plane is directly opposite to the Eye; or when the Eye is in the Axis of the Plane.

3. Of a *Right Circle*, whose Plane is Coincident, (that is, falling one upon another) with the Axis of the Eye, or with the Visual Ray, and passes thro' the Center of the Primitive.

4. An *Oblique Circle* whose Plane lies Oblique to the Axis of the Eye, so that it makes unequal Angles with it.

Spots in the Sun, or *Maculæ*. 'Tis certain, those Opake Masses which we see through the Telescope at the Sun, are not Planets revolving at any, even the least distance from him; but Spots, adhering to him, revolving but once in about 25½ Days; by which we come to know the Sun's Rotation round its Axis.

Stars, are those glorious sparkling Diamonds in the Canopy of Heaven, moving in that wonderful Order which was given them at the Creation by the Almighty *Tetragrammaton*, who then *gave them a Law that shall not be broken*, Psalm cxlviii. 6. of which there are two sorts, *viz.* Fixed and Earratic; which Words see.

Station

Station in Astronomy, signifies certain Places in the Zodiac, where a Planet being arrived, seems to stand still for some time in the same Degree and Minute, and is, their being Stationary; which always happens just before and after their being Retrograde. See *Point of Station.*

Succession of the Signs, is that Order in the which they are usually reckoned; as, first, *Aries*, *Taurus*, *Gemini*, &c. See *Signs.*

Summer, one of the four Quarters or Seasons of the Year; which see.

Summer-Solstice. See *Solstice.*

Sun, was one of the seven Planets (but is now exempted) and resteth fixed in the Center of the Planetary System, and gives Light, Heat, and Motion to all the seven Planets. By the Poets he is called *Apollo*, *Itios*, *Phœbus*, *Titon*, and thus marked ☉. His Chariot is drawn by four very swift Horses, whose Names are *Æolus*, *Æthon*, *Phlegon*, and *Pyrois.*

Sun's Beams. A Star or a Planet is said to be under the Sun's Beams until they be more than 17 Deg. elongated from his Body, either before or after him; for till then they cannot be seen with the naked Eye.

Sunday Letter. See *Dominical Letter.*

Superiour Planets, are *Mars*, *Jupiter* and *Saturn*; they are so called, because they move in Orbits round the Sun, which are larger than that of our Earth, and so are above us with regard to the Sun, and can never come between our Earth and him.

Swift in Motion. All the Planets are swift in Motion when their mean Anomaly are six Signs.

Syderial Year. See *Siderial.*

Symbols, are Marks or Signs of things invented by an Artist, and peculiar to several Sciences, by which the knowledge of the things themselves is always more expeditiously, and most times, more clearly convey'd to the Learner; especially after a little he hath enured himself to them. What Symbols I make use of in this Treatise, are these following:

Given

' *Given.*	⊞ *Cube.*
o *Required.*	√ *Root.*
R. *Radius, or Retrograde.*	S. *Sine.*
+ *Plus, more.*	C. S. *Co. Sine.*
— *Minus, less.*	Sec. *Secant.*
× *Multiplication.*	C. Sec. *Co. Secant.*
÷ *Division.*	T. *Tangent.*
= *Equal to.*	C. t *Co. Tangent.*
cr. *Side.*	º *Degrees.*
crs. *Sides.*	' *Minutes.*
< *Angle.*	'' *Seconds.*
<< *Angles.*	.·. *As.*
z *Sum.*	: *To.*
X *Difference.*	: : *So is.*
□ *Square.*	△ *Triangle.*

Sydonical Anomaly, in the Moon's Syſtem, is, the Aggregate of all her Anomalies in one, *viz.* her Mean, Equated, Correct, and Laſtly, her Synodical Anomaly.

Synodical Month, is the ſpace of time, *viz.* 29 Days, 12 Hours, 45' contained between the Moon's parting from the Sun at a Conjunction, and returning to him again; during which time ſhe puts on all her Phaſes.

Synodical Revolution, is that Motion whereby the Moon's whole Syſtem is carried along with the Earth round the Sun.

Syſtem, properly, is the regular, orderly Collection or Computation of many things together. In Aſtronomy, the Syſtem of the World is the Order wherein the Planets move round the Sun, of which there are ſeveral ſorts; but are all exploded except the *Copernican*.

Syzygia in Aſtronomy, is the ſame with Conjunction of any two Planets, or Stars; or when they are referred to the ſame Point in the Heavens; that is, being in the ſame Sign, Degree, and Minute of the Ecliptic, by a Circle of Longitude paſſing through them both.

T.

T*Ables Aſtronomical*, are ſuch as are annexed thereunto.

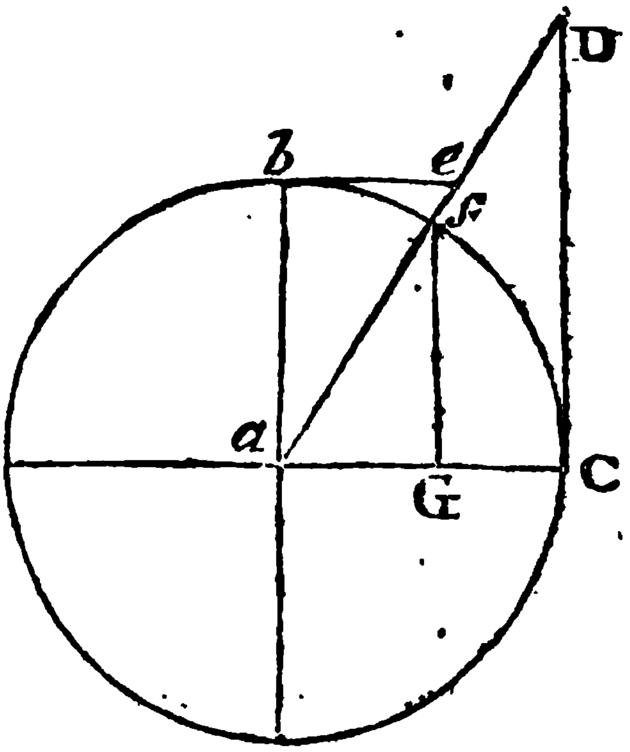
Tangent of an Arch or Angle in Geometry, is a right Line drawn without the Circle perpendicular to the Radius as C B and C D, and *b e* are Tangents in the following Figures.

By

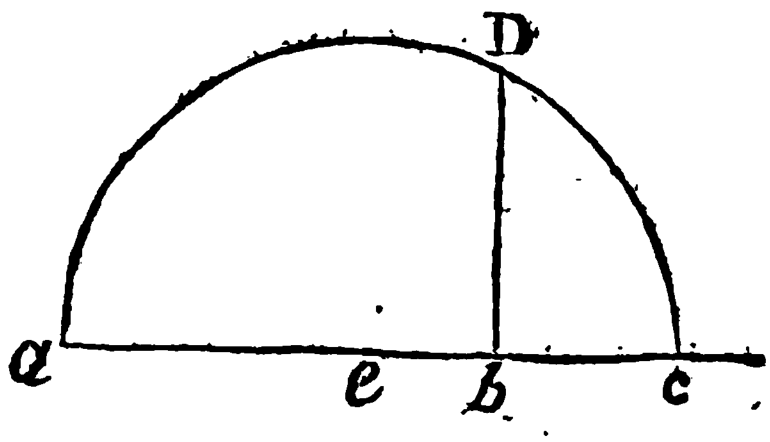
Note, That Radius is a Mean Proportional between the Tangent of an Arch, and the Tangent Complement of the ſame Arch.

Demonſtration per Euclid 13, 6.

Take the Tangent c D and ſet it from *a* to *b*, in the lower Diagram ; take the Co. Tangent *b e*, and ſet it from *b* to *c* : Biſſect *a c* in *e*, on *e* as a Center with the Radius *e a* = *e c* ; ſtrike the Semicircle *a* D *c* ; at *b* erect a Perpendicular to touch the Periphery at D ; ſo ſhall *b* D be the Geometrical Mean, and is equal to the Radius *a b* of the upper Diagram.



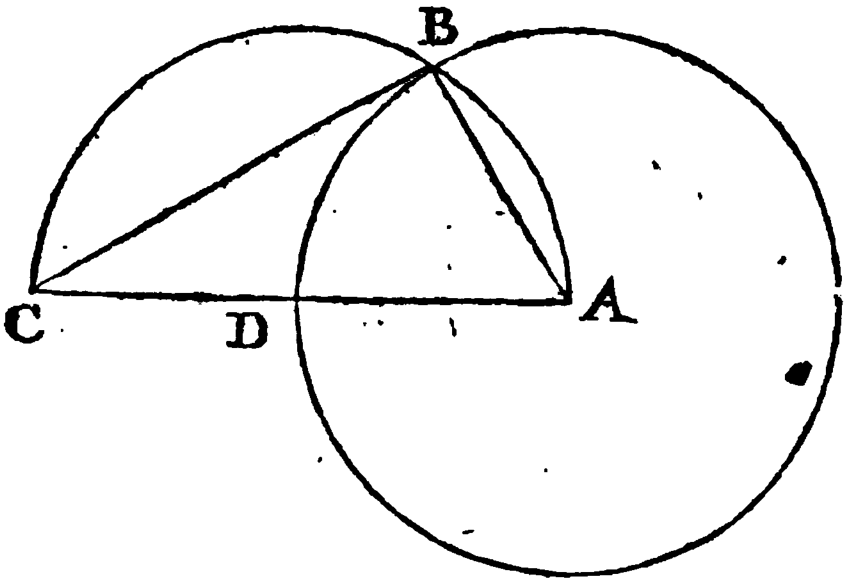
Alſo Radius is a Mean Proportional between the Sine of an Arch, and the Secant Complement of the ſame Arch, as is proved above.



To

To draw a Tangent-Line to a given Circle.

Open the Compasses to any convenient Extent, and on the Center A, draw the given Circle; set one Foot in D (in any part of the Circumference) and sweep the Semicircle A B C; draw A B, the Radius of the given Circle from its Center, to



the Circumference where the Semicircle intersects it; then draw B C to meet the Diameter of the Semicircle at C, and 'tis done; so shall B C be a true Tangent to the given Circle, as was required: Because the Angle A B C is a right Angle, as being made in a Semicircle; as *per Euclid* 31, 3.

Or which is better, set the Radius from B to D, and from D to C, draw B D, and 'tis done.

Taurus, is the second Sign in the Zodiac, unto which the Earth comes about the 19th Day of *October*; it is marked thus ♉, and in Calculations numbred with the Figure 1.

Telescope, is an Instrument by which we discover Objects at a distance: Of which there are two sorts, *viz.* the Refracter and Reflecter; of the latter there are the *Newtonian* and *Gregorian*; which though very fine Inventions, yet they labour under such Inconveniencies as render them hitherto of no great use; which is likely to continue as long as the metaline Speculum is subject to tarnish: So that for cœlestial Observations, the Refracting Telescope is by much the best.

Telescopical Stars, are those that are not visible to the naked Eye, but discoverable only by the help of a Telescope.

Temperate Zone, are two Spaces on the Earth contained between the two Tropicks and Polar Circles. See *Zone*.

Terms, at *Westminster*; there be four every Year, during which Time Matters of Justice are dispatched.

The first is called *Hillary-Term*, which begins the 23d of *January*, and ends the 12th of *February*.

The second is called *Easter-Term*, which begins (always) the *Wednesday* Fortnight after *Easter-Day*, and ends the *Monday* next after *Ascension-Day*.

The third is called *Trinity-Term*, it begins the *Friday* next after *Trinity-Sunday*, and ends the *Wednesday* Fortnight after.

The fourth is *Michaelmas-Term*, which begins the 23d Day of *October*, and ends the 28th Day of *November* next following. *Note*, that *Easter* and *Trinity-Terms* are moveable; and how to find them yearly you will meet with in a Table following.

Terms, begin three Days sooner at *Doctors Commons* than at *Westminster*.

Oxford Terms, are four, *viz. Hillary*, or *Lent-Term*, begins *January* the 14th, ends the *Saturday* before *Palm-Sunday*.

Easter-Term begins the 10th Day after *Easter*, exclusive; that is *Wednesday* Sev'night following, ends the *Thursday* before *Whitsuntide*.

Trinity-Term begins the *Wednesday* after *Trinity-Sunday*, ends after the Act sooner or later, as the Vice-Chancellor and Convocation please.

Michaelmas-Term begins *October* 10, ends *December* 17. *Note*, the *Monday* after the 6th of *July* the Act begins.

Cambridge-Terms; *Lent-Term* begins *January* 13, ends the *Friday* before *Palm-Sunday*.

Easter-Term begins the *Wednesday* Sev'night after *Easter*, ends the *Thursday* before *Whit-Sunday*.

Trinity-Term begins the *Wednesday* after *Trinity-Sunday*, ends the *Friday* after the *Commencement*.

Michaelmas-Term begins *October* 10, ends *December* 16. *Note*, the first *Tuesday* in *July* the *Commencement-Act* begins.

The *Irish-Terms* are the same as *Westminster*, except that *Michaelmas-Term*, which begins *October* 13, adjourns to *November* 3, and from thence to the 6th; it hath seven Returns.

The *Scotch-Terms*.

Candlemas-Term begins *January* 23, ends *February* 12.

Whitsuntide-Term begins *May* 25, ends *June* 1

Lammas-

Lammas-Term begins *July* 20, ends *August* 8.

Martinmas-Term begins *November* 3, ends *November* 29.

The two Learning-Vacations in the four Inns of Court, *London*, *viz.* the two *Temples*, *Lincoln's-Inn*, and *Gray's-Inn*, begin the first *Sunday* in *Lent*, and the first after *Lammas-Day*, and continues three Weeks and three Days.

N. B. If the Beginning and End of any of these Terms fall on *Sunday*, then the Beginning or Ending of the same is on *Monday* next following.

Terraqueous Globe, signifies the Terrestrial Globe, from *Terra* and *Aqua*; that is, Earth and Water; as they both together constitute one spherical Body.

Theorem, is when something is proposed to be demonstrated.

Time, is a certain Measure depending on the Motions of the heavenly Bodies, by which the Distance and Duration of things are measured.

Time of Incidence, is the time from the Beginning to the Middle of an Eclipse, and in the Moon's Eclipse is always equal to the Time of half Duration.

Time of Repletion, is the Time from the middle of a solar Eclipse, to the end thereof.

Torrid Zone, is the Space on the Earth between the two Tropics. See *Zone*.

Transit in Astronomy, signifies the passing of any Planet just by, or under any other fixed Star; or of the Moon covering, or going close by any other Planet: Also the Transits of *Venus* and *Mercury* over the Sun's Disk are understood in the same sense; that is, when they pass between us and the Sun, so as to make a black Spot on his Body.

Tredecile, or *Sesquiquintile*, is a new Aspect of 3 Signs, 18 Degr. and marked thus T. d.

Trine Aspect, is the Distance of 120 Degr. or 4 Signs, and is marked thus △.

Triplicate Ratio, in four continual Proportionals, is the Proportion of the first Term to the fourth. As, in these four Numbers, which are proportional 2 : 4 : 6 : 12. See *Proportion*.

Tropics, are two lesser Circles of the Sphere, parallel to the Equinoctial, and 23 Degr. 29 Min. distant therefrom, being the Bounds or Limits of the Sun's greatest Declination, North and South. That which lyeth between the Equinoctial and north Pole, is called the *Tropic* of *Cancer*; and the other between the Equinoctial and the south Pole, the *Tropic* of *Capricorn*. When the Earth is arrived to the *Tropic* of *Capricorn*, which is about the 10th Day of *June*, she maketh longest Days

to all the northern Inhabitants; and returning towards the Equinoctial, when being arrived to the *Tropic* of *Cancer*, which is about the 10th of *December*, she then makes longest Nights and shortest Days to all that dwell on the North side of the Equinoctial; and to those that live in south Latitudes, just the contrary Appearances. You must understand, that the Sun is always apparently diametrically opposite to the Earth.

Tropical Points, are the very Points where the Ecliptic toucheth the two *Tropics*, which is in the very beginning of *Cancer* and *Capricorn*, where the Solstitial Colure cuts them.

True Place. See *Place*.

Twilight, is that dubious half Light which we perceive before the Sun-rising and after Sun-setting. 'Tis occasioned by the Earth's Atmosphere, and the Splendor of the *Æther* which environs the Sun. The Ethereal accended Atmosphere of the Sun, not setting so soon as, and rising before the Sun; and the Sun's Rays also illuminating the Earth's Atmosphere before the Body of the Sun can appear, occasions a Light always preceding at the rise, and subsequent to the setting of that glorious Body: Which, though because of many accidental Variations in both the Sun's and Earth's Atmosophere, it cannot be always of the same Degree of Duration or Brightness; yet it usually holds in the Evenings, till the Sun is about 18 Degrees below the Horizon, and appears so long before his rising in the Morning. But from a due Consideration of the Sphere it self, it will be easy to determine in any Latitude where the Parallel of Declination intersects the Parallel of 18 Degrees: For to the Complement of the Latitude, add the Complement of the Sun's Declination, and the distance of the Parallel of 18 Degr. from the Zenith (which always is 108 Degr.) if the half Sum of these three be equal to 108, then that is the Day the Parallel of Declination cuts the Parallel of 18 Degr. on which Day the Sun has such Declination as makes up that Sum above-named, and is the Day that there begins to be no Night, but Twilight, which is about *May* 11; and when the Sun has passed the Tropic, there is another Day of the same Length with the former, which in this our Latitude of 51° 32' North, will be found to be *July* 10, on which Days the Sun has the same Declination, and consequently must rise and set at the same Hours: So that from *May* 11 to *July* 10 there is no Night but Twilight. But when the half Sum above-mentioned is more than 108 Degr. then there is perfect Darkness at Midnight; proved thus, See the Work,

Sun's

	°	'
Sun's distance from the Zenith ———	108	0
Co. Latitude subtract ——— ———	38	28
Sun's distance from the North Pole ———	69	32
Whose Complement is the Sun's Declination	20	28

Look the Days of the Month answering this Declination of the Sun, and you will find them to be *May* 11, when the Twilight ceases, and *July* 10, when it begins to be perfect Night again at *London*.

Example 2. At *Madrid* whose Latitude is 40° 10', what Day doth the Twilight cease, and when doth it again begin?

	°	'
Parallel of Twilight ——— ———	108	0
Co. Latitude subt. ——— ———	49	50
Rem. ——— ——— ———	58	10

This being less than the Sun's least distance from the north Pole 66° 31', shews there is perfect Darkness all the Month of *June* in that Latitude. Which how to work you will find in the *Doctrine of the Sphere*.

Tychonian System, is that Hypothesis framed by *Tycho Brahe*, in which he puts the Earth at rest, as the Center of the Moon and fixed Stars; but the Sun moving round the Earth, is the Center of the Primary Planets. I have exploded this System.

V.

Vacuum, is by Physiologists supposed to be a Space devoid of all Body; and the Planetary Regions in which the Heavenly Bodies move, must needs be such; for otherwise a Resistance must accrue to the Planets Motions, which though never so small, would in time be sensible, and have an effect in retarding the Motion of the heavenly Bodies: But no such thing hath yet ever been observed or discovered, though the contrary is certain. Besides, such a thin Vapour as the Tail of a Comet, can move through the *Æther*, (as some call it) with incredible swiftness, without being dissipated or drawn from it's Natural Course; which is in it self a Demonstration that there must be a kind of Vacuum in those Celestial Regions.

Variation in Astronomy, See *Angle of Reflection*.

Vector,

Vector, a Line supposed to be drawn from any Planet moving round the Sun, or Focus of the Ellipsis, by which it describes proportional Areas in proportional Times.

Venus, is the Name of one of the seven Planets, and is the most splendid of all the Primary Planets: For when she is Occidental, and at her greatest Elongation from the Sun, she often shines so bright as to cast a Shadow on the Earth; she has her Increase and Decrease in Light as the Moon, and moves in an Orb between the *Earth* and *Mercury*, making her Revolution round the Sun in 224d. 46h. 19' 24'', and is never found further off the Sun than 47°. 38' 35''. She has the least Eccentricity, but the greatest Geocentric Latitude: For when Retrograde in ♒, she will have more than 8 Degr. north Latitude; and when Retrograde in ♍, her Latitude will be 9 Degr. south. Every eight Years you may nearly find her in the same place of the Heavens. She is called *Aphrodite*, *Cytheria*, *Erycina*, and marked thus ♀.

Vertex, is that Point in the Heavens, just over our Heads, and the same with *Zenith*; which see.

Vertical Circles, the same with *Azimuths*, which see.

Vesper, the Evening.

Vespertine in Astronomy, when a Planet sets after the Sun, it is said to be *Vespertine*.

Via Lactea, the same with *Milky-Way*, which see.

Vindemiatrix, a fixed Star of the third Magnitude in the Constellation *Virgo*.

Virgo, one of the twelve Signs of the Zodiac, but the sixth in Order, and thus marked ♍; but in Astronomical Calculations, numbered with the Figure 5. The Earth enters this Sign about the 8th Day of *February*.

Visible Conjunction of the Sun and Moon (in Astronomy) is that which is seen by an Eye from the Earth's Superficies, which always differs from the Time of the true Conjunction, except they be conjoined in the Nonagesime Degree; and then the true and visible or apparent time is the same: The reason of which difference is, that the true Conjunction is made by a Line supposed to be drawn through the Earth's Center; and the Visible, by a Line from its Superficies: From hence it will follow, that if the true Conjunction fall in the Oriental Quadrant, that is, between the Nonagesime Degree and the Eastern Horizon, the Moon's Place is put forward by the Parallax of Longitude, and then will the Visible Conjunction be before the True. But if the True Conjunction fall in the Occidental, that is, between the Nonagesime Degree and the Western Horizon,

Horizon, the Moon's Place is then retarded, or put back so much as is the Parallax in Longitude; consequently the Visible or Apparent Conjunction will follow the true Time. The Knowledge of these are of very great Importance in the Calculation of Solar Eclipses.

Umbelicus, in an Ellipsis, is that Focus about which the Motion of a Planet is made, and which it respects as its Center: So that either Focus may be called by this Name.

Under the Sun's Beams, is when a Star or Planet is within 17 Degr. of the Sun's Body, either before or after him; so that then they cannot be seen with the naked Eye.

Universe; the whole Mass of material Beings, as, Heaven, Earth, Stars, &c. are called by this Name.

Volva, the great *Kepler*, considering how our Earth will appear to the Inhabitants of the Moon, if there be any such; *viz.* that it will seem a large Moon to them 15 times greater than their Planet doth to us at the Full; in 24 Hours time revolving round its Axis, (as will be easily discoverd by the Spots that must appear in it) but yet also fixed like a fixed Star in one determinate Place in the Heavens, and moving only as they appear to do. This being the Phænomenon of the Earth to a Lunar Spectator, *i. e.* to such as live on that side of the Moon which is always turned towards the Earth, for those in the other Hemisphere can never see the Earth at all.

Vortex, according to the *Cartesian* Philosophy, is a System of Particles of Matter moving round like a Whirl-Pool: By this they endeavoured to solve the Motions of the Heavenly Bodies. But Sir *Isaac Newton* proved it false; and therefore it is exploded.

Uraniburg. Any Place where you view or contemplate the Heavens and heavenly Motions, may bo called by this Name.

Urania, the heavenly Muse.

Uranoscopia, a View of the Heavens. The Name of which I give one of my Books of Astronomy lately publifhed, in which I demonstrate the Equation of Time, the general Phenomena of Solar Eclipes, demonstrating both the *Keplerian* and *Flamsteedian* Methods, with many other useful and curious Things, and useful Tables, too many to be enumerated here.

Ursa major, the *Great Bear*, called also by the *Greeks*, *Arctos* and *Helice*; being a northern Constellation consisting of 27 Stars; and it is also called *Charles's Wain*.

Ursa minor, the *Lesser Bear*, called by the *Greeks Arctos*, whereupon the north Pole is called the *Pole Artic* or *Helice minor*; because of the small Revolution which it maketh round

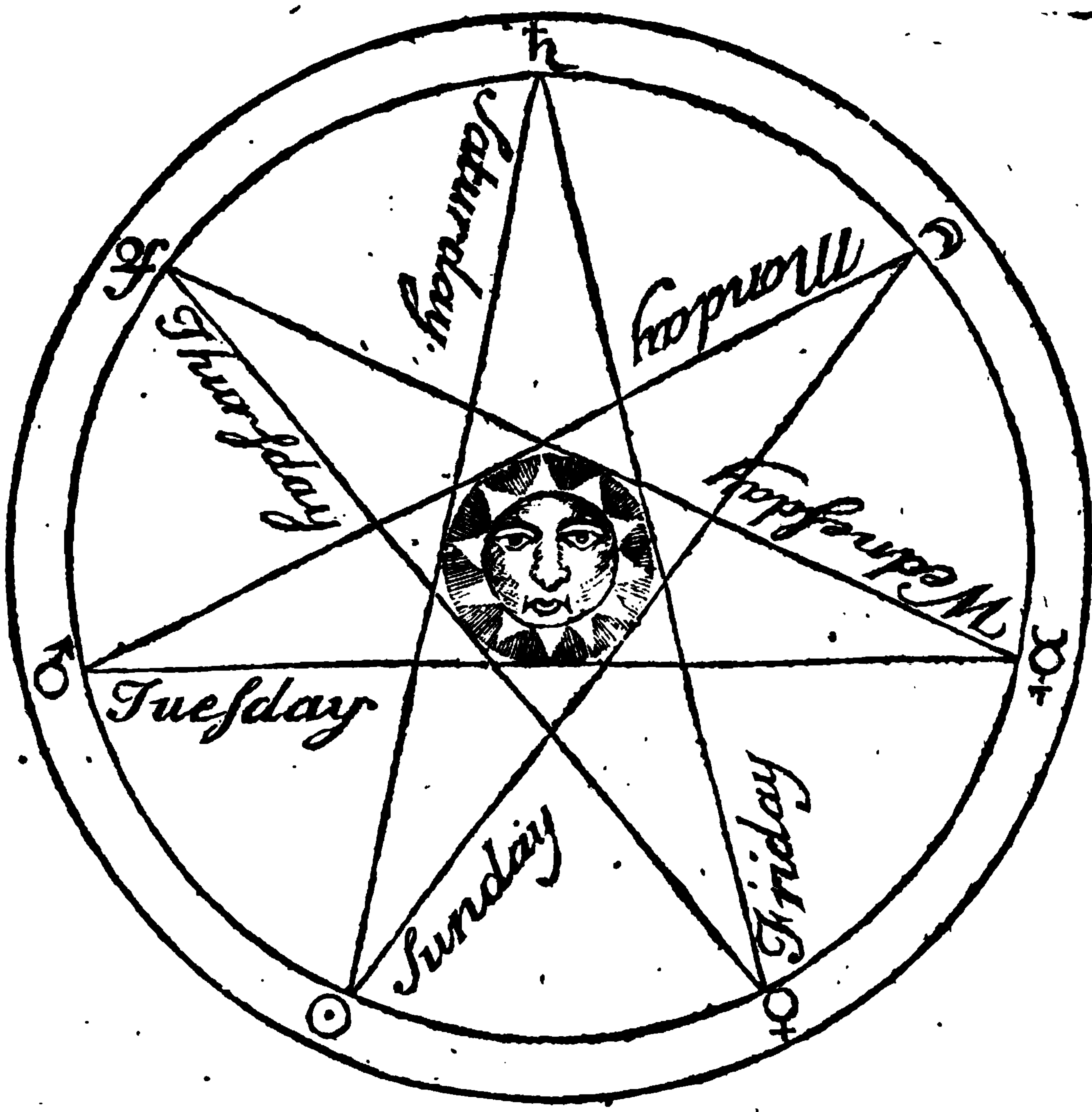
about

about the Pole; or rather of *Elice*, a Town in *Arcadia*, wherein *Galisto* the *Great Bear*, and Mother of the *lesser* was bred. It is likewise called *Cynosura*, because though it carrieth the Name of the *Bear*, yet it hath the Tail of a *Dog*. These two last Constellations never rise nor set in the Horizon of *London*.

W.

*W*EEK-*Day*.

The HEBDOMADE.



By this Scheme it is plain how the Ancients came to give Names to the Days of the Week, and the Planets to be Lords thereof: For first you see the seven Planets are placed in their Order

Order round the Figure as they are in the Heavens: First *Saturn* which is the highest Planet, then *Jupiter*, then *Mars*, *Sol*, *Venus*, *Mercury*, *Luna*: Where at ☉ we find *Sunday*, signifying *Sol* to be Lord on *Sunday*, that Line directs you to *Monday*, where you find *Luna* Lady of that Day; from that the Line directs to *Tuesday*, where we find *Mars*, Lord; the Line from that directs you to *Wednesday*, where you find *Mercury*, Governor of that Day at Sun rising; a Line from thence directs you to *Thursday* which *Jupiter* Rules; from thence you are directed to *Friday*, where we find *Venus*, Lady; the Line from thence directs to *Saturday*, where we find *Saturn* sole Governor of that Day at Sun rising: And thus the Reader is informed how the seven Planets came to be made Governors of the seven Days of the Week.

The Word *Hebdomade*, signifies the Number of Seven, Ages, Years, Months, *&c.* but most commonly Days.

Winter Quarter, one of the four Seasons of the Year. See *Quarter*.

Winter-Solstice, is, when the Sun apparently enters the first Minute of the Tropical Sign ♑, making longest Nights and shortest Days to all the northern Inhabitants. It happens about the 10th of *December*.

Welkin, the same with *Firmament*, which see.

X.

XIphias, the *Sword-Fish*, a southern Constellation

Y.

YEar, is the time the Sun apparently takes to go through the twelve Signs of the Zodiac. This is properly the Natural or Tropical Year, and contains 365d. 5 h. 48′ 57″; during which space of time all the Variety of Seasons are celebrated.

Z.

ZEnith, is the Point in the Heavens right over one's Head, being diametrically opposite to the *Nadir*, and is always 90 Degr. distant from the Horizon: And here Note, that the Arch of the Meridian between the *Zenith* and the *Equinoctial*, is always equal to the Arch of the Meridian contained between

the Horizon and the Pole; which is the same with the Latitude of the Place.

Zodiac, is a Zone or Girdle, surrounding the Heavens, and cutting the Equinoctial at oblique Angles at *Aries* and *Libra*, = to 23° 29′, being equal to the Sun's greatest Declination; and in the middle of this Zodiac lies the Ecliptic or *Via Solis*, the apparent way of the Sun and Earth. The Breadth of the Zodiac is 18° 30′; for that will take in the Latitude of all the Planets; less Breadth would do only for the Planet *Venus*, who has sometimes 9 Degr. of Latitude: The Zodiac is equally divided into twelve parts called *Signs*, and Eleven of these twelve represent living Creatures, *viz.* all but *Libra* the *Ballance*; for the rest are the *Ram*, the *Bull*, the *two Naked Boys*, the *Crab-Fish*, the *Lion*, the *Virgin*, the *Scorpion*, the *Shooting-Horseman*, the *Goat*, the *Water-Bearer*, and the *two Fishes*.

Zone in Geography, is a Space of Earth or Sea, contained between two Parallels of Latitude; and there are five in Number, *viz.* two Frigid, or Frozen; two Temperate, and one Torrid, or burning Zone.

The Frigid, are those Parts of the Globe comprehended between the Poles and the Polar Circles: Therefore one must be toward the North, and the other toward the South. In the north Frigid Zone lies *Iceland*, *Lap-land*, *Finmark*, *Samajeda*, *Nova-zembla*, *Green-land*, and some part of *North America*.

The south Frozen is not yet known, whether it contains Land or Water. They are in Breadth each 46° 58′. These Inhabitants are called *Periscii*, because their Shadow goes round them.

The Temperate Zones lie one on the North side the Equator, between the Artic-Circle and the Tropic of *Cancer*; the other on the South side between the Tropic of *Capricorn* and the Antartic Circle. Each of these is 42 Degr. broad. These Inhabitants are called *Heteroscii*: They cast their Shadow but one way.

The Torrid or Burning Zone contains all that Space between the two Tropics: The Breadth of this is 46° 58′ equal to the Breadth of each of the Frigid Zones. The Inhabitants of this Zone are called *Amphiscii*, because they cast their Shadow round them; that is, at Noon sometimes towards the North, and sometimes towards the South.

THE DESCRIPTION And USE of the SECTOR.

SECTION I.

BEcause the Projection of the Sphere, and Geometrical Construction of Solar Eclipses, are best performed by a Sector; and it being that which I shall all along in this Treatise make use of, I think it not impertinent to give my Reader a Page or two in the Description and Use of that Universal and most useful Instrument.

Euclid in his 9th Definition of his Third Book, says, That a Sector is a Figure contained under two Semidiameters, and the Arch which serves them for a Base.

This Instrument is commonly made of Silver, Brass, Ivory, or Box-wood, in Length 6, 8, 9, and 12 Inches, with a Joint like a Carpenter's Rule; so that the said Legs, together with certain right Lines, drawn from the Center of the Joint, contain Angles of different Quantities. The Lines that are commonly drawn upon the Face of this Instrument, to be used Sector-wise, are the Lines of Lines or equal Parts, numbred with

1, 2, 3, to 10, and marked with L L; the 1 may sometimes stand for 10, the 2 for 20, or 200, &c. according as the matter in Hand requireth. Next these lies a Line of Chords issuing from the Center, and marked with C C at the End, and numbered 10, 20, 30, &c. to 60°; which Chord of 60 is equal to the Radius of a Circle, or whole Sine of 90 by Prop. 15. Book 4. of *Euclid*.

On the other Face of the Sector is a Line of Natural Sines, numbered with 10, 20, 30, &c. to 90, and marked at the End with S S. By the sides of the Sines lie two Lines of natural Tangents issuing from the Center also, and numbred with 10, 20, 30, &c. to 45°; because the Tangent of 45, Sine of 90, and Chord of 60, are all equal to the Radius of a Circle: These Tangents are marked at the End with T T. Between the Sines and Tangents on each Leg is a Line of lesser Tangents, issuing from two little brass Centers, and there beginning to be numbred with 45, 50, 60, 75, and marked with *t. t.*

This Line supplies the Line of greater Tangents when your Angle exceeds 45°. And on the same Face with the Chords, and equal Parts or Line of Lines, lies the Lines of natural Secants, issuing from two little brass Centers lying betwixt the Chords and Line of Lines, and numbred with 20, 30, 40, 50, 60, 70, 75, marked with S S. These Chords, Sines, Tangents, and Secants, are all projected from the same Circle to the Radius of the Sector they are placed upon.

There are other Lines arbitrarily placed upon the Sector; but tending nothing to my present purpose, I shall not therefore trouble the Reader with their Description or Use at this time.

U S E.

1. The Use of this Instrument is so very great through all the Branches of Practical Mathematics, that it ought to be written in Letters of Gold.

And *First*, I must explain the meaning of two Words generally made use of in the Use of the Sector, *viz. Lateral* and *Parallel*.

When we say the *Lateral Line of Lines*, *Sines*, *Tangent*, or *Secant*, we mean, that Line which is found upon the Face, or Side of the Sector. And to take off a Parallel, Sine, &c. is to set one Foot of your Compasses on the Sine of 40, &c. on one Leg, and the other Foot on 40 on the other Leg.

A

A Parallel Radius is when one Foot is set in the Sine of 90 Degrees, or Tangent of 45, or Chord of 60, on one Leg, and the other Foot on 90, 45, and 60 on the other Leg.

The *Line of Lines* are actually divided into 100 equal parts each; but we have only 10 put to them, which may signify either themselves alone, or 10 times themselves, or 100 times themselves, or 1000 times themselves, as occasion shall require; so that when you lay down or take off any Number of equal Parts, set 10, 10 to the given Radius, and set one Foot of your Compasses on one Number, as suppose 70, and the other Foot on 70 on the other *Line of Lines*, and this Extent is either 7, 70, 700, 7000, &c. according as the nature of your Question requires.

These Line of Lines are useful to encrease, or diminish a Line in a given Proportion; to divide a given Line into any Number of equal Parts; to find the Proportion between two or more given Lines; to find a third Proportion to two given Lines; or three Lines being given to find a fourth Line proportional to them; to find a mean Proportional between two given Lines; or, to divide a Line in such a manner, as another Line is already divided.

2. To open the Sector, that the two Lines of equal Parts may make a Right Angle, if the whole lateral Length be applied over between 8 and 6; because □ 8 + □ 6 = 100, by 47 of the first of *Euclid*; and the Line of Lines then on the Sector will stand at a Right Angle.

3. The Line of Lines may be opened to a Right Angle, if the lateral Sine of 90 be applied over parallel between 45 Deg. and 45 Degr. in the Sines; or if the lateral Line of 45 be applied parallel over the Line 30, and 30.

4. Line of Chords may be opened to any particular Angle, by taking out the lateral Chord of the Angle required, and applying it over in the Parallel of 60, 60; and you will have those Lines severally to stand open at the Angle proposed.

Example, I would open the Line of Chords to an Angle of 20 Degrees.

Take the lateral Chord of 20, and apply it over Parallel on 60, 60; and then those Lines stand open at an Angle of 20, as was required.

5. On the contrary, if the Sector be opened to an Angle at venture, you may find the quantity of it thus, *viz.* take the parallel Chord of 60 Degrees, and measure it on the lateral Chord, and that will give the Angle that the Line of Chords then stands at. And observe the same of the Lines of Sines,

by

by confidering that the Sine is half the Chord of the double Ark. As, if it were required to open the Sector in the Lines of Sines to an Angle of 40; take out the lateral Chord of 40, and to it open the Sector to the Chord of 60; fo fhall the Lines of Sines be opened to the Angle required. Or if the *Semi-radius* be applied over between the Sine 30 and 30, it will open the Lines of Sines to that Angle: That is, divide the Chord of the given Angle, as suppofe 40, into two equal Parts; and that Extent of the Compaffes fet over the Sine 30, 30 will open the Lines of Sines to an Angle of 40, the like of any other Angle.

Example, I would open the Lines of Sines to an Angle of 45 Degrees.

Divide the lateral Chord 45 into two equal Parts, and lay that Extent parallel over the Sines 30, 30, and that fhall open the Lines of Sines to an Angle of 45 Degrees.

Note, It is one thing to open the Edge of the Sector to an Angle, and another thing to open the Lines on the Sector to the fame Angle: For when the Sector is clofe fhut, the Edges of it make no Angle; but the Lines of Lines, Sines, Tangents and Secants, make then an Angle of near 6 Degrees.

6. If you would examine the Lines of Chords, Sines, Tangents and Secants, whether they be truly made, project them from a Circle of the fame Radius; and if you would prove if the Sines and Chords are truly projected from the fame Circle, then open the Sector-Lines ftraight out at length, and take the Sine 10, 10; that is, fet one foot of your Compaffes on 10, on one Leg, and extend the other to 10 on the other Leg in a ftraight Line; carry this Extent to the Line of Chords; fet one foot in the Center, and the other foot will exactly reach to the Chord 20 Degr. if your Sector is truly made. The fame obferve of any other Degrees on the Sine.

7. To lay down an Angle of any quantity of Degrees.

This may be performed, either by the Lines of Chords, Sines, Tangents, or Secants, due regard being had to each particular Line.

1. By the Chords. Take the defign'd Radius in your Compaffes, and open the Sector in 60, 60, on the Line of Chords; then take parallel-wife the given Angle in your Compaffes, and lay it down, and 'tis done.

Do fo for the Sines, by applying the Radius over the Sine 90, 90; and the Tangent if lefs than 45, over 45, at the end of the Line, but if your Angle exceed 45 Degrees, then you muft

must set the Radius over the lesser 45, where are two small brass Centers nearer the Joint of the Sector; also your Secants must be taken from those Centers, on the other Face of the Sector, where 'tis marked at the end with *S*, or sometimes with *Sec.*

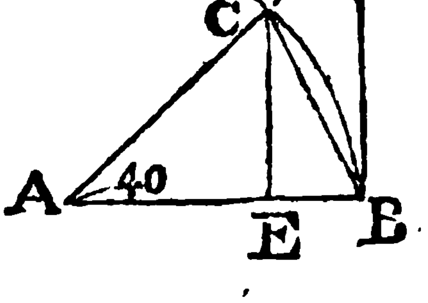
Example. Let it be required to lay down an Angle of 40 Degrees by the Lines of Chords, Lines, Tangents, and Secants on the Sector. Draw A B equal to your proposed Radius, and strike the Arch; which take in your Compasses, and set one foot in 60 of the Line of Chords; open the Sector till the other foot fall in 60 on the other Leg of the Sector. Now it is fitted to the given Radius; so that any quantity of Degrees may be laid down or measured to answer that Radius. But in the present Example 'tis only 40 Degrees. Take therefore 40 from the Line of Chords parallel-wise and set it on the Arch B C; Draw A C, and the Angle B A C is an Angle of 40 Degrees as was required.

But if your Angle exceed 60 Degrees then you must take half, and lay it down twice; as suppose 80 Degrees, take the Chord of 40, and turning it on the Arch twice, shall give you the true Chord of 80: And so of any other above 60.

2. By the Sines. Take A B in your Compasses, and open the Sector on 90, 90, to that Extent; then take off the parallel Sine of 40 Degrees, and set one foot in *C*, the other will reach to *E*, and that is the Sine of the Arch B C, which measures Angle B A C.

3. By the Tangents. Take A B in your Compasses, and open the Sector on the Tangents of 45 Degrees to that Extent; then take off the Tangent of 40 parallel, and set one foot in B, and the other will reach exactly to D; then is B D the Tangent of the Arch B C 40 Degrees.

4. By the Secants. Take A B in your Compasses, and open the Sector on the small brass Centers which lye towards the Joint of the Sector to that Extent; then take off the parallel Secant of 40, and it will reach from A to D; so is A D the Secant of the Arch B C, and that measures the Angle B A C 40 Deg. as was required.



And thus may any right-lined Angle be either measured or laid down, by the Line of Chords, Sines, Tangents, and Secants. And if you have occasion for the Natural Versed Sine of any Ark under 90, it may be had by subtracting the Natural Sine of the same Ark

Ark from the Radius; the Remainder is the Complement of the Versed Sine required; thus,

From Radius Sine of	90°	is	10.000000
Natural Sine of	40	sub.	6.427876
Natural Versed Sine of	50	is	3.572124

And the versed Sine to any Angle above 90, is had, by adding the Natural Sine's Excess above 90 to the Radius: Thus,

To Radius	90°		10,000000
Add Natural Sine of	40	add	6.427876
Versed Sine of	130	is	16.427876

And the Secant of any Ark is had by subtracting the Co. Sine out of the double Radius: Thus,

Double Radius	20,000000
An Angle of 40, its Co. Sine is	9.884254
The Secant of 40 is	10.115746

See my young *Mathematician's Companion*.

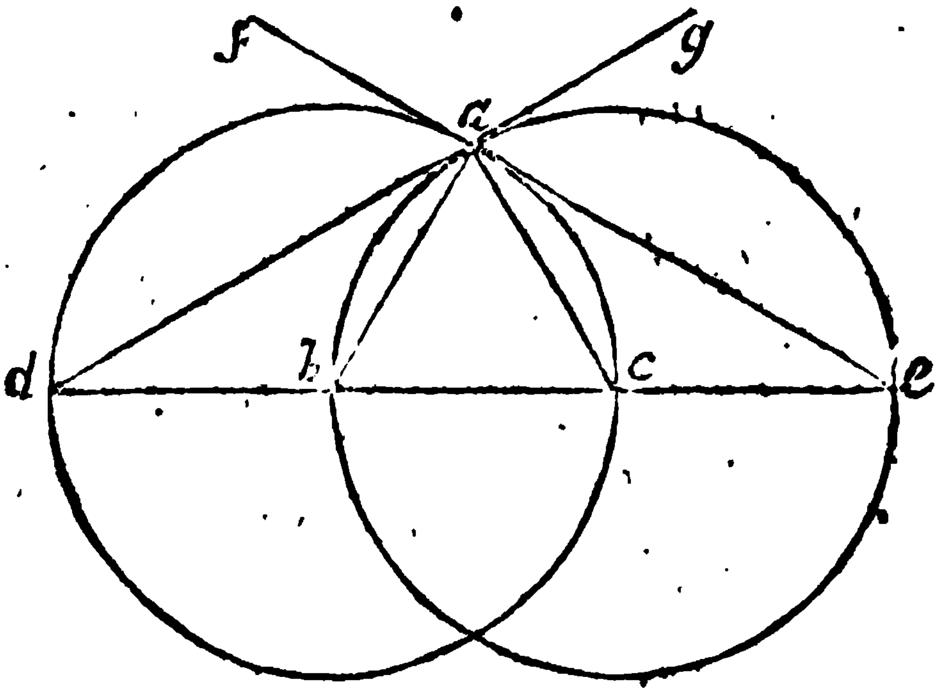
SECTION II.

Of Spheric Geometry.

WHoever would be an Astronomer, it is very requisite that he be well-grounded in Numbers; and thereby acquainted with *Euclid's* Elements; and that he may the better go through the *Doctrine of the Sphere*, I shall hear subjoin a few Propositions introductory to the Projection of the Sphere on any Circle.

1. The

1. The Angle of Intersection of any two Circles on a Plane, is equal to their Angle made by their *Radii*, drawn from their Centers, to the Point of Intersection.

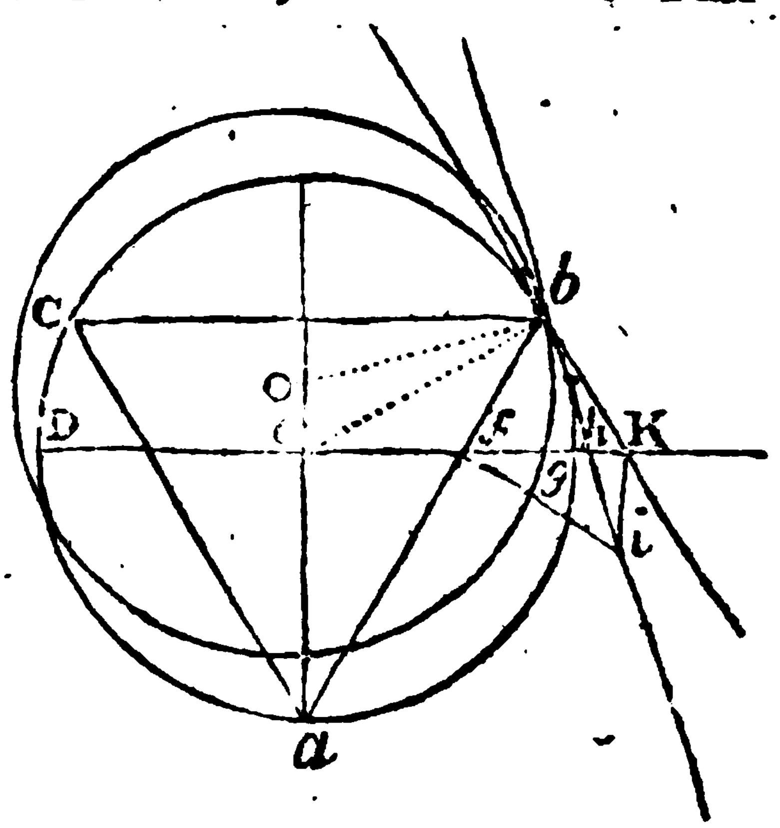


Construction. To the Point of Intersection *a*, draw *a e*, a Tangent to the Circle *a c d*, and *d a*, a Tangent, to the Circle *b a e*.

Demonstration. Because the infinitely small Portions of the Circles, do coincide with the Tangents, and consequently have the same Direction; therefore the Curv'd Lin'd Angle *b a c*, formed by the two Circles, is equal to the Right Lin'd Angle *d a f* = *b a c* 60°: And because the Angle *d a c* = Angle *b a e* is a Right Angle, take away from each the interjacent Angle *d a b* = *c a e*; there will remain the Angle *b a c* = Angle *f a d* = Angle *g a e*, which was to be demonstrated.

2. All Angles made by Circles on the Superficies of the Globe, are equal to those made by their Representatives on the Plane of the Projection.

Suppose the Eye at a; project the Spherical Angle $g\,b\,h$, and draw the Tangent $b\,k$ to the Circle $b\,h$; also draw the Tangent $b\,i$ to the Circle $g\,b$; from the Point b, draw $b\,c$ parallel to $D\,h$, and join $a\,c$; draw $k\,i$ at Right Angles to $D\,k$, to meet the Tangent $b\,i$ in i; and then draw $f\,i$. Now by the 32, 3 *Euclid*, the Angle $k\,b\,a, =$ *Angle* $a\,c\,b = a\,b\,c$ *per Euclid* 21, 3; and $b\,f\,k =$ *Angle* $k\,b\,f$ *per* 29, 1: Therefore $b\,k = f\,k$ by the 6, 1. Then in the Triangles $i\,k\,f$, $i\,k\,b$, $i\,k$, $k\,f = i\,k$, $k\,b$, and the Angle $i\,k\,f$ Right.



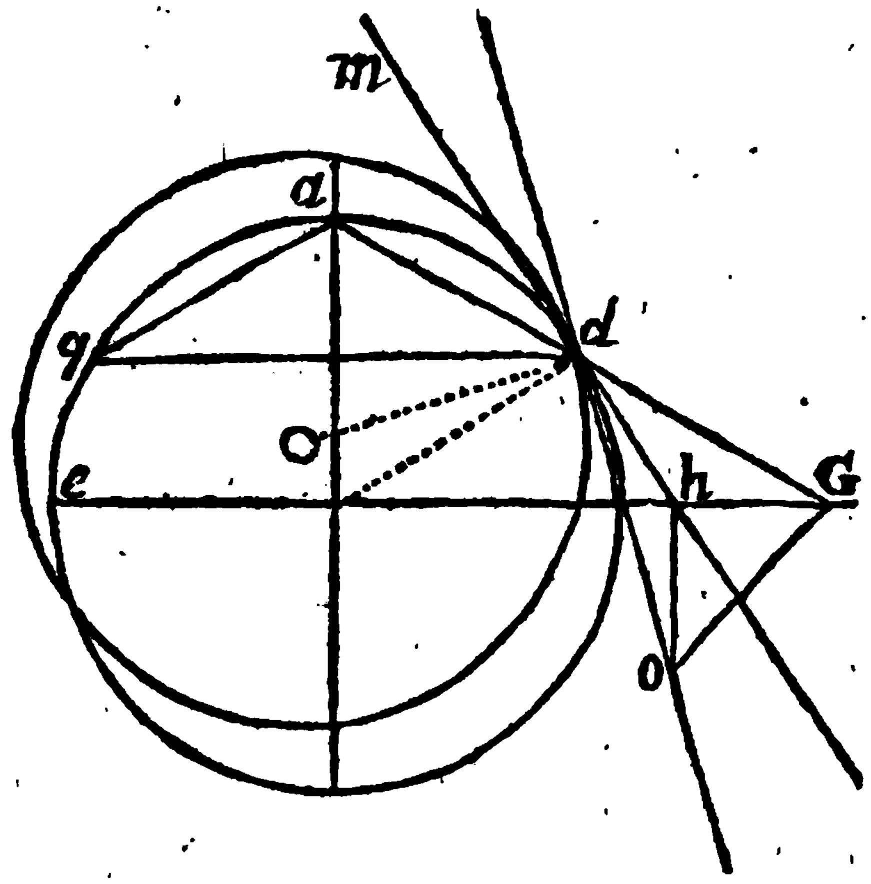
Wherefore the Angle $i\,f\,k$ upon the Plane of the Projection, is equal to the Angle $i\,b\,k$, forming the Spheric Angle $g\,b\,h$; which proves the Angle made by the Circles is equal to the Angle made by their Tangents. For the Eye at a, projects the Tangent $b\,k$ in $f\,k$, and the Tangent $b\,i$ in $f\,i$; the Angles $i\,f\,k$, $i\,b\,k$ being both bounded by $i\,k$.

Or as in the following Scheme, draw all the Line; then will the Angle $a\,d\,m$ be equal to the Angle $a\,q\,d$, (in the opposite Segment) which is $= q\,a\,d$; because the Δ is an *Isosceles*; but the *Angle* $q\,d\,a =$ *Angle* $b\,g\,d$; because $q\,d$ is parallel to $e\,g$; therefore the *Angle* $b\,g\,d =$ *Angle* $a\,d\,m =$ to the verticle *Angle* $b\,d\,g$; wherefore the Δ $b\,d\,g$ is an *Isosceles*, and consequently $d\,b$ is $= b\,g$.

Hence the Triangle $O\,d\,b$, hath two Sides, $o\,b$ and $b\,d$, and *Angle* $o\,b\,d =$ to two Sides, and one *Angle* in the Δ $o\,b\,g$.

Wherefore

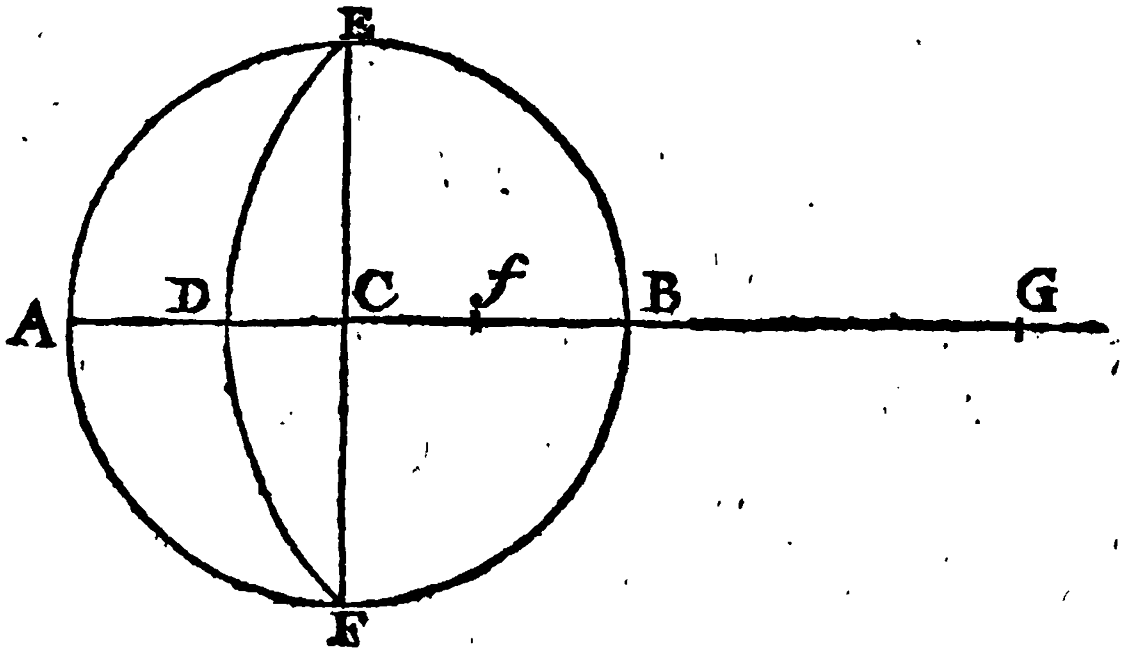
Wherefore all things are equal, and consequently the *Angle* $o\,b\,g$ = *Angle* $o\,d\,b$ = to the Curvilineal Angle made by the two Circles.



PROPOSITION I.

Any Point being given, to find another Point diametrically opposite unto it.

IF the Point given be in the Primitive *Circle*, then from it draw a right Line through the Center, and it will cut the Primitive diametrically opposite; as here let E be the given Point, a right Line drawn from E through the Center to F in the Primitive, will be the opposite Point to E as was required.

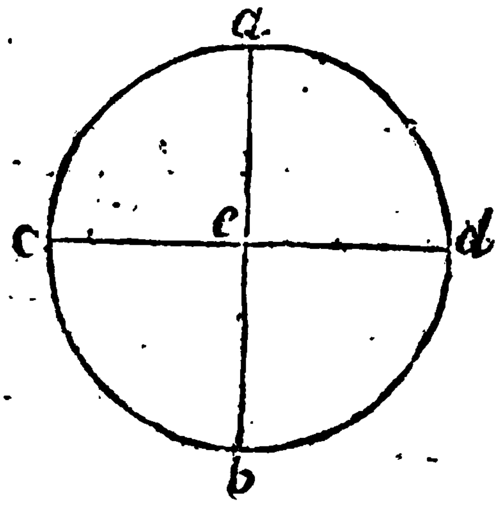


2. If the Point given be somewhere within the Primitive, as D: to find the Point diametrically opposite thereto; do thus, open the Sector to the Radius of the primitive Circle A C = C B, and take off the distance D C and measure it on the Tangents, which I find to be 22° ½, then take the Tangent of its Complement *viz.* 67° ½, and set it from C to G, so is G the opposite Point sought. *Note*, Because the Circle E D F, is swept on the Center B, with the Chord of 90°; therefore the Angle A E D is = 45°: for the Chord of 90° is equal to the Secant of 45°. Consequently D C must be the Semitangent of 45 = to the Tangent 22 ½.

PROP. II.

To find the Pole of any great Circle.

1. EVery Circle has two Poles: If it be the Primitive Circle, its Poles are at *e*, the Center.



2. If the Pole of a Right (*c d*) or Perpendicular (*a b*) be sought. 'tis 90 Degrees distant upon the Limb from the Point where the Circle cuts it. So the Pole of *a b* is *c* and *d*; and the Poles of *c d* are *a* and *b*.

The Poles of every small Circle are the same with the Poles of that great Circle to which they are Parallel.

PROP. III.

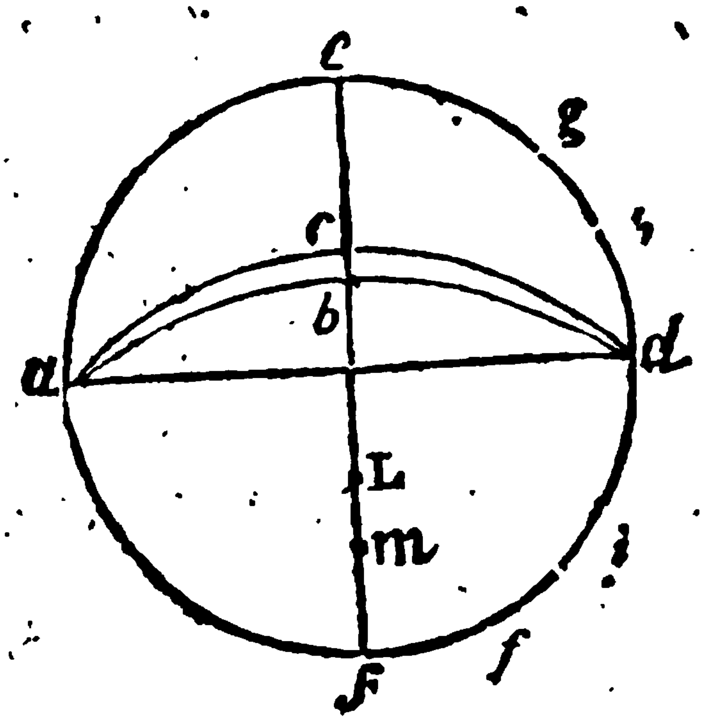
To find the Poles of an Oblique Circle.

First, Consider that this Circle must cut the Primitive in two opposite Points, as in the Case of all great Circles.

2. The Pole of this Circle must be in a Line perpendicular to its Plane.

3. This Circle's Pole must always lye between the Center of the Primitive, and its own.

Let



Let $a\,b\,d$, and $a\,c\,d$, be two oblique Circles, whose Poles are required. A Ruler laid from a to b and c, gives g and h; take the Chord of 90 Degrees, and set it from g to k, and from h to i. Then a Ruler laid from a to k and i severally gives m, and L the two Poles sought: So m is the Pole of the Oblique Circle, $a\ b\ d$, and L of the Circles $a\ c\ d$.

Note, The Pole of every Circle falls in the Diameter of that Circle, one within the Primitive and the other without.

Lastly, The Poles of an oblique Circle, may be found thus. Let the Poles of the Oblique Circle, E D F in the Figure page 75 be sought. Set the Sector to the Radius of the Primitive A C, and measure D C on the Lines of Tangents, which I find to be 22° ½. Substract 22° ½ from 45° (always) and the Remainder 22° ½, take from the Tangents, and set from C to f, so is f the Pole of the Oblique Circle, which falls within the Primitive. Add D C 22° ½ to 45°, the Sum 67° ½ take from the Tangents, and set from C to G; so is G the other Pole, and always falls without the Primitive Circle.

If the Pole f, be given to describe the Circle E D F, measure Cf on the Tangents, and lay the Tangent C F twice the Degrees of Cf, 22° ½ = 45° from C to B, so is B the Center of the Circle E D F as was required.

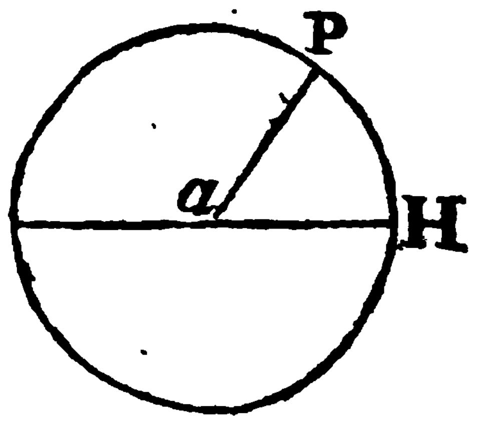
PROP. IV.

To lay down on the Projection any Angle required.

Here are three Cases.

1. The Angle at the Center of the Primitive.
2. In the Periphery.
3. Any where in the Circle; but neither in the Center nor Periphery.

First,

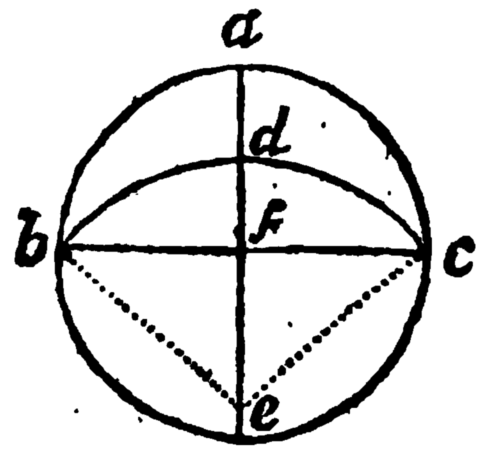


First, An Angle at the Center is laid down by the Line of Chords on the Periphery thus: I would have an Angle of 51° 32'. Take the Chord of 51° 32' and set it from H to P, draw P *a*, and 'tis done. For the Angle P *a* H is 51° 32'.

Secondly, That the Angle-Point may be in the Periphery.

RULE.

Take the Secant of the given Angle in your Compasses, and set one Foot at *b*, where you design the Angular Point, and with the other make a Mark in the Diameter at *e*, that shall be the Center of a Circle that shall make an Angle at the Circumference, as was required. *Example*, I would have an Angle of 40 Degrees, and the Angular Points to be at *b* and *c*.

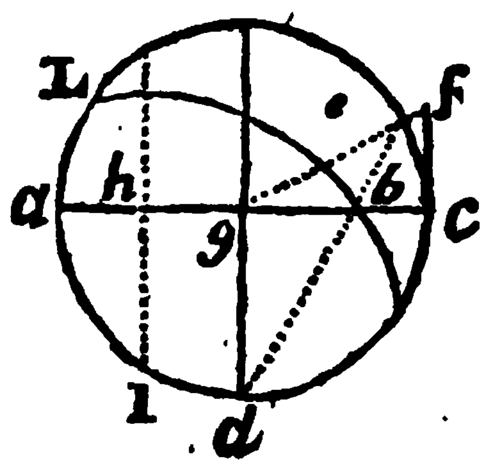


Open the Sector to the Radius of the given Circle *f a*, on the Line of Secants, and take off the Secant of the given Angle 40 Degrees; carry this Extent, and set one Foot in *b* or *c*, and with the other make a Mark in the Diameter at *e*; set one Foot in *e*, and sweep the Arch *b d c*, so shall the Angle *a b d* = *a c d* be an Angle of 40 Degrees as was required.

Thirdly, To make a Spheric Angle, where the Angle-point is in any Point given within the Periphery, but not in the Center or Periphery.

Example.

Example. I would make an Angle of 50 Degrees at the Point *b*.



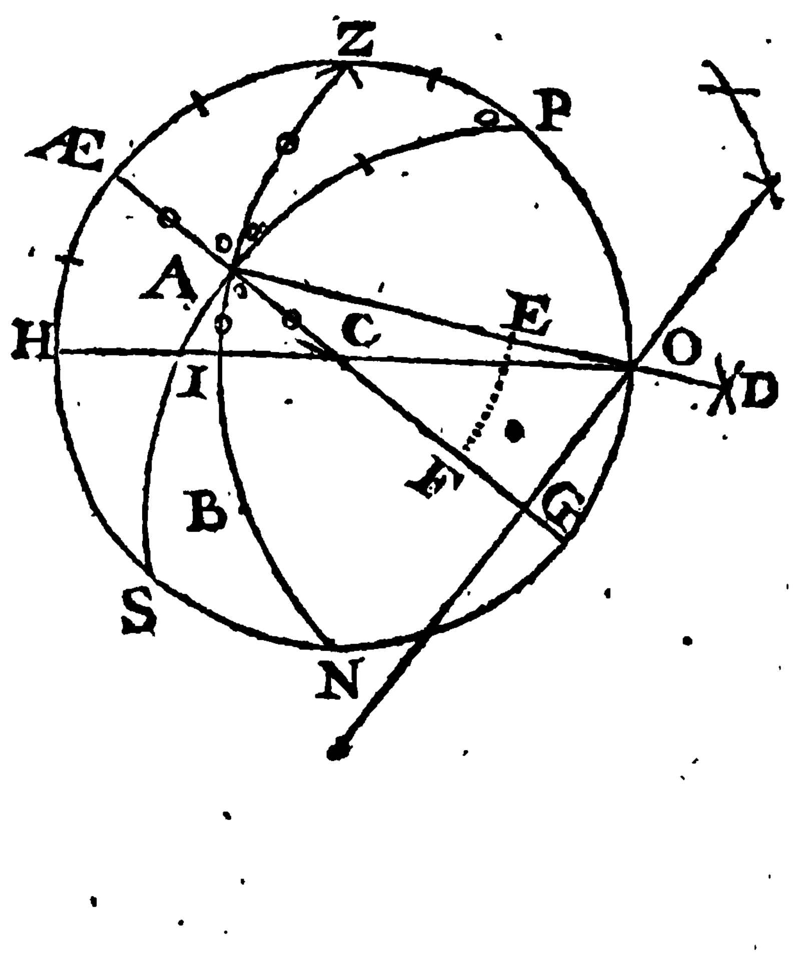
Rule. Lay a Ruler from *d* to the given Point *b*, and it gives *e* in the Periphery. Draw *g e* to meet the Tangent *c f*; take *c f*, and set from *g* to *h*; draw *h i* parallel to *d g*; take the Co. Tangent of the given Angle, *viz.* 40 Degr. and set it from *b* to *i*, so is *i* the Center; on which draw (with the Radius *i b*,) the Arch *b L* so is the Angle *a b L* 50 Deg. as was required.

Fourthly, To make a Spherical Angle when the Angular Point is neither in the Center, Periphery, nor made by any right Circles, but by two Oblique Circles some where within the Primitive.

Example. Let HZON, be the Meridian of the Place HO, the Horizon ÆG, the Equinoctial to the Elevation of *London* ZAN an Azimuth, and let it be required to make an Angle at A, by an Hour Circle, to make an Angle of 26° 6′ with the Azimuth ZN.

Practice. Having drawn the Meridian, Horizon, and Equinoctial as above-mentioned.

1. With the Secant of 45° set one Foot of the Compasses in O, and draw the Azimuth ZABN, (by which means the Angle ÆZA is 45°).



2. Make

2. Make A B equal to A Z, and open the Compasses to any convenient Extent, setting one Foot in Z and B, severally sweep the Arches at D, and draw A D and it will be at right Angles to the oblique Circles Z A B N.

3. Open the Compasses to the Chord of 60°, (to any Radius) set one Foot in the Angular Point at A, and draw E F, take the Chord of the given Angle 26° 6′ and set it from E to F.

4. From the Angular Point at A, draw A C G through the Center.

5. Measure A C on the Tangents which is here 25° 58′, double is 51° 56′ its Complement is 38° 4′.

6. Take the Tangent of 38° 4′ and set from C to G.

7. Through the Point G draw the Line G O, at right Angles to A C G: Now where the Line G O cuts the Line A C G (which is here at G) is the Center of the other oblique Circles P A S, which draw, and it will make the Angle Z A P, equal 26° 6′ as was required. *Note*, all great Circles which pass through the Point A, have their Centers in the Line G O, as you will see more at large when you come to project the Sphere on the Plane of the Horizon.

To Exercise the young Student in Spherics, I shall here insert all the parts of the Triangles.

1. In the oblique Angled Spheric Triangle *A Z P*.

		°	′			°	′
Side	A P =	90	00	Angle	A Z P =	135	00
	A Z =	60	41½		Z P A =	38	4
	Z P =	38	28		Z A P =	26	6

2. In the Triangle *Y Æ Z*.

		°	′			°	′
Side	Æ Z =	51	32	Angle	A Æ Z =	90	00
	A Z =	60	41½		Æ A Z =	63	54
	Æ A =	38	4		Æ Z A =	45	00

3. In the Triangle *A I C*.

		°	′			°	′
Side	A C =	51	56	Angle	A I C =	90	00
	I C =	45	00		I A C =	63	54
	I A =	29	18½		I C A =	38	28

P R O B. IV.

PROP. V.

To measure any Spheric Angle, when projected.

Here are three Cases.

1. When the Angel point is at the Center of the Primitive Circle.

2. When the Angle-point is at the Periphery.

3. When the Angle-point is within the Primitive, but not in the Center.

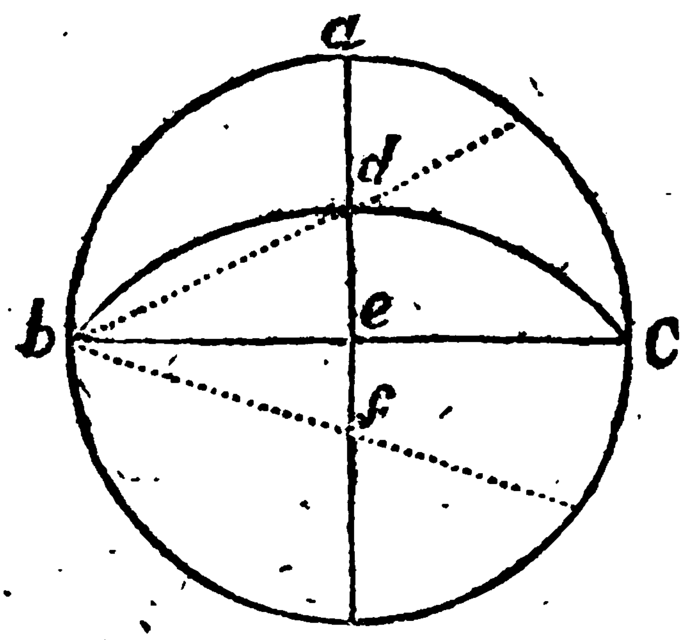
First, To Measure an Angle at the Center of the primitive Circle.

You have no more to do, than to take the Arch in your Compasses that is terminated by the two Legs of the Angle, and apply it to the Line of Chords, and 'tis done; which being so plain, needs no Example.

Second, To Measure a Spheric Angle, the Angle-point being at the Circumference.

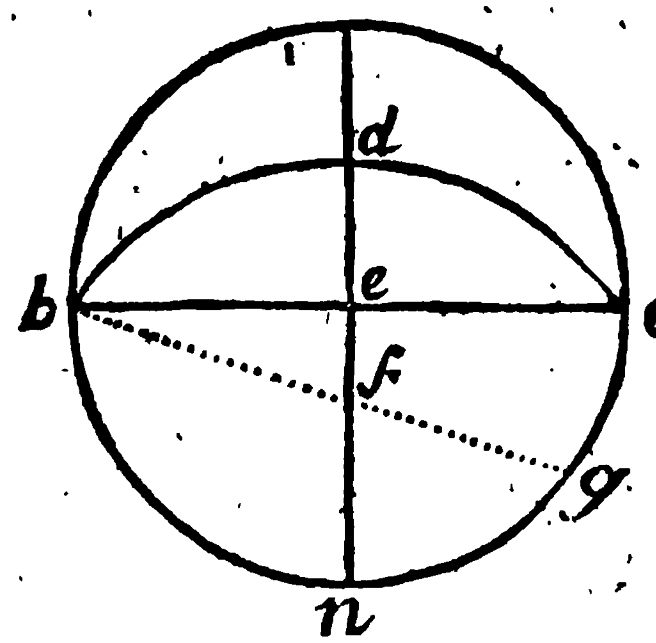
RULE.

By *Prop.* 2. find the Pole of the given oblique Circle; then measure the Distance on the half Tangent between the Center of the Primitive and the Pole of the oblique Circle, and that's the Quantity of the Angle sought.



Example. Let the Angle *a bd* be required: *First*, The Pole of the oblique Circle *b d c* is at *f*, the distance *e f* on the Semi-Tangents is 40, the quantity of the Angle *a b d* = *a c d*.

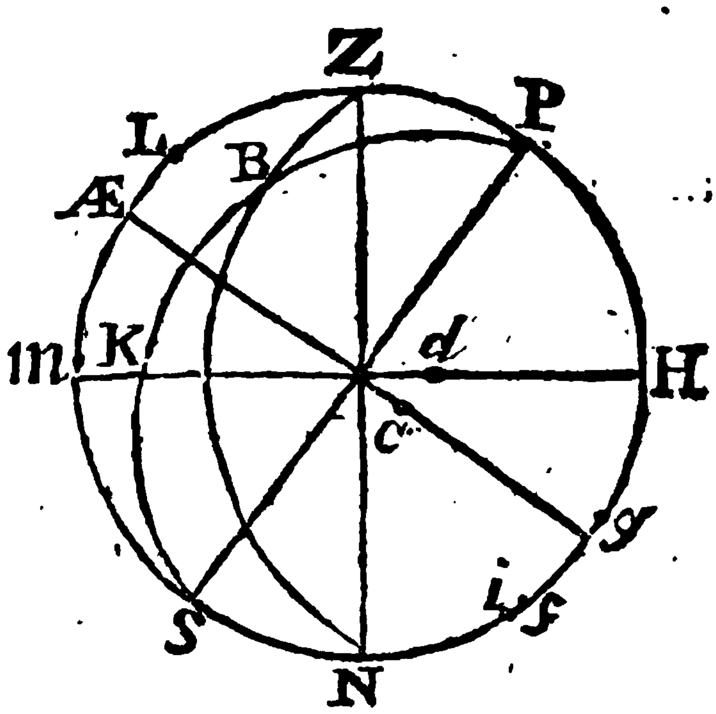
But if the two Poles are not in the same Diameter, then lay a Ruler to the Angle-point, and to those Poles severally, and that will reduce them to the primitive Circle; which measure on the Line of Chords, as was taught in the first hereof.



Example. Let the Angle *d b e* be required to be mea-sured: *First*, The Pole of the Right Circle *b c* is at *n*, by *Prop.* 1. and the Pole of the oblique Circle *b d c*, is at *f*; lay a Ruler from *b*, the Angle-Point to *f*, gives *g* in the Circumference; and laid from *b* to *n*, gives *n*; the Chord *n g*, is 50 Degr. the quantity of the Angle sought.

Thirdly, To measure a Spheric Angle when the Angle-Point is within the Primitive, but not in the Center.

Rule. Find the Poles of the two oblique Circles that limit the Angle to be mea-sured by *Prop.* 2; and a Ruler laid to the Angular Point, and to those Poles severally, will reduce the An-gle to be measured, to the Primitive Circle; which mea-sure on the Line of Chords, as by the first hereof.



Example. Let it be required to Measure the Angle P B Z.

First, Draw the Diameter *Æ æ* of the oblique Circle P B S the Pole thereof falls at *c*. *Secondly*, Draw the Diameter M H of the oblique Circle Z B N, the Pole thereof falls at *d*; a Ruler laid from B the Angular-Point to *c* and *d* severally, gives *f* and *g* in the Primitive; the Arch *f g* measured on the Line of Chords is 18 Degrees, the quantity of the Angle required.

PROP. V.

PROP. VI.

To measure the quantity of Degrees of any Arch of a great Circle.

1. If the Arch be part of the Primitive, 'tis measured on the Line of Chords.

2. If the Arch be any part of a right Circle (that is, a Diameter that passes through the Center of the Primitive) then lay a Ruler from the Pole of the right Circle, to the two Extremities of the Portion of the right Circle that is to be measured, and it will give you two Points in the Primitive; which measured on the Line of Chords, is the quantity of the right Circle in Degrees and Minutes, as was required.

Example. In the last Scheme, if it were required to measure the Part *e d*, of the right Circle K H, I lay a Ruler to *z*, its Pole, and to *e* and *d*, gives N and *i* in the Primitive; then open your Sector to the Radius *e* N, *&c.* and take off N *i*, and applying it parallel on the Line of Chords, gives 30 Degrees, the quantity of *e d*, as was required.

Or, the Portion of any right Circle may be measured by the Scale of half Tangents; supposing the Center of the Primitive to be in the beginning of the Scale; so that if the Degrees are to be reckoned from the Center, you must account according to the Order of the Line of half Tangents.

But if the Degrees are to be accounted from the Periphery of the Primitive (as will often happen) then you must begin to account from the End of the Scale of half Tangents, calling 80, 10; 70, 20. *&c.*

3. To measure any part of an oblique Circle.

First, Find its Pole; there lay the Ruler; reduce the two Extremities of the Ark required to the Primitive Circle, and then the distance between these Points on the Chords, is the Quantity sought.

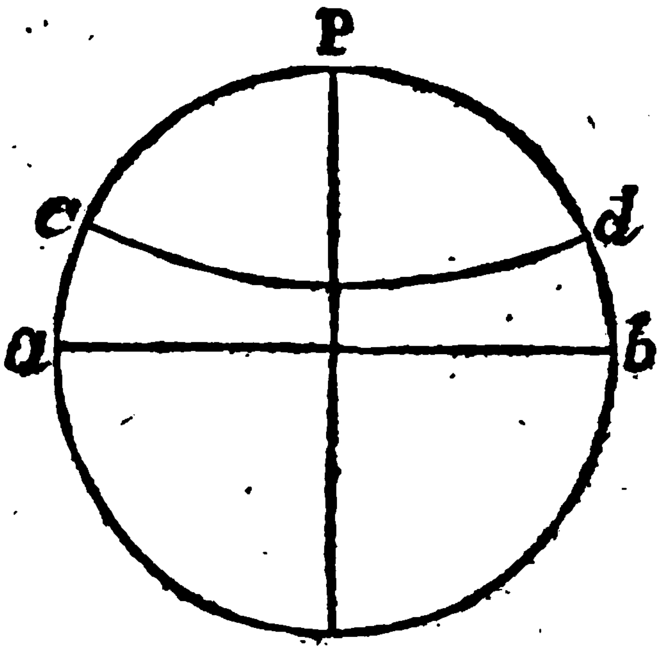
Thus in the last Figure, if the Quantity B K of the oblique Circle P B S were required, a Ruler laid to its Pole at *c*, and to B and K, will give the two Points L, *m*, in the Primitive, which distance L *m*, on the Line of Chords is 63 Degrees, which is the Quantity of B K, as was required.

PROP. VII.

To draw a Parallel Circle.

1. If it be to be drawn parallel to the Primitive Circle, at any given distance, draw it from the Center of the Primitive with the Complement of that distance taken from the Line of half Tangents.

2. If it be to be drawn parallel to a Right Circle; as, suppose *c d* parallel to *a b* were to be drawn at 23° ½ distant from it; from the Chords take 23 Deg. ½, and set it on the Primitive from *a* to *c*, and from *b* to *d*; or set its Complement 66° ½ from P the Pole of *a b*, to the Points *c* and *d*.

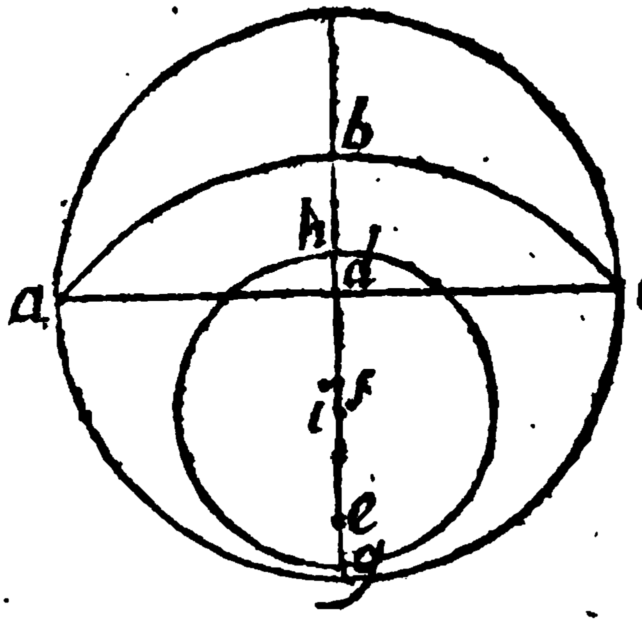


Then take the Tangents of the parallel distance from the Pole of the right Circle *a b*, which is here 66 ½; set one Foot of the Compasses in *c* and *d* severally, and make two occult Arches, whose Intersection shall be the Center of the Circle *c d*; and thus are the Tropics and Parallel of Declination drawn in the Stereographic Projection.

3. If it be to be drawn Parallel to an oblique Circle.

Rule. From the Line of half Tangents, lay off the parallel distance from the Pole of the oblique Circle given, both ways in that Diameter of the Primitive Circle; and note those Marks: Then these Points bissected, give the Center of the Parallel sought.

Example. Let it be required to draw a Circle parallel to the oblique Circle *a b c*, at the distance of 40 Degrees. *First*, find *f*, the Pole of the oblique Circle; the Measure *d f*, the distance of the two Poles on the half Tangents, which you will find to be 34 Degrees; to which add 50 (the Complement of the designed Parallels distance from



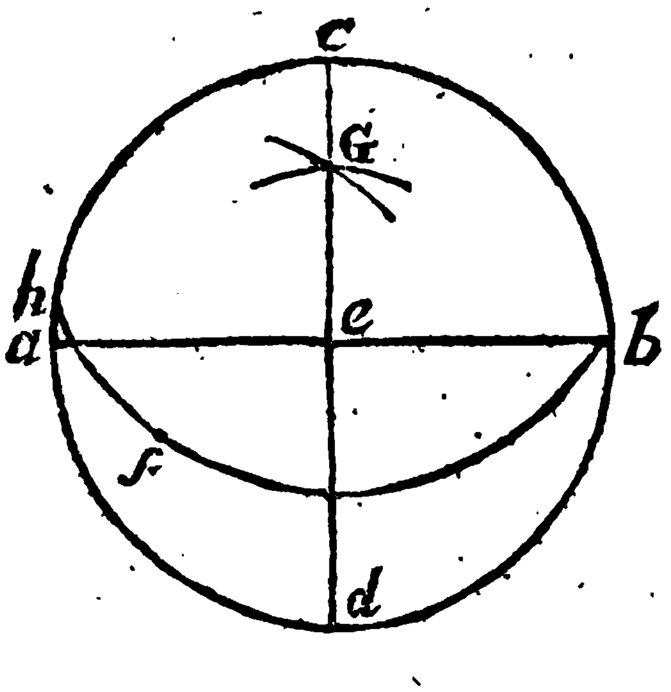
50
34
Z 84
X 16

the oblique Circle) to the Sum of 84; set off the half Tangents from *d* to *g*; then take the difference between 34 and 50=16, and set it from *d* to *h*; bissect *g h* in *i*; so is *i*, the Center of the required parallel Circle.

Note, By this *Prop.* is the Path of the Vertex of any Place drawn in the *Copernican* Projection.

PROP. VIII.

To draw a great Circle thro' any Point making with the Primitive Circle any given Angle.



Rule 1. With the Tangent of the given Angle, set one Foot in the Center; describe an Arch.

2. With the Secant of the same Angle, set one Foot in the given Point; strike an Arch, crossing the former; the Intersection of these two Arches is the Center of the Circle required.

Example. Let it be required to draw a great Circle through the given Point *f*, and to make an Angle with the Primitive of 30 Degrees,

Open

Open the Sector to the Radius c e, and take off the Quantity of the given Angle of 30 Degrees; set one Foot of the Compasses in the Center of the Primitive Circle at e, and sweep the Arch at g: Open the Sector to the Radius as above, at the little Center of the Sector, and take off the Secant of 30; set one Foot of the Compasses in the given Point f and strike the other Arch at g; the Intersection of the Arches at g is the Center of the oblique Circle h f b, which passes through the given Point f, and makes an Angle with the Primitive of 30 Degrees as was required.

PROP. IX.

To draw a great Circle thro' any two given Points within the Periphery of the Primitive Circle.

RULE.

1. Through either of the given Points and the Primitive Circle's Center, draw a Diameter, produceth it beyond the Perimeter.

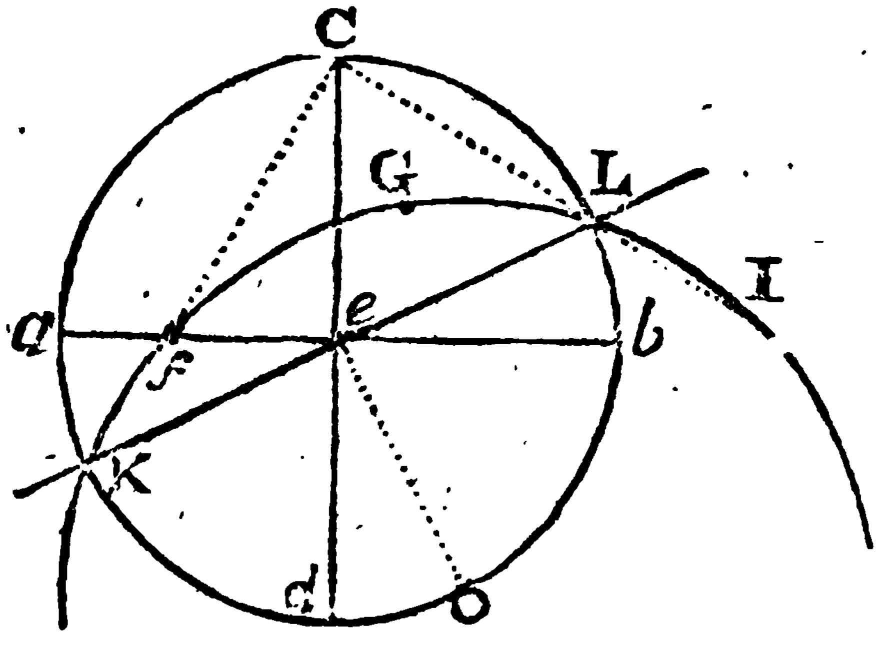
2. Cross this Diameter at right Angles.

3. Through the Point mentioned draw a Line to the Extremity of the second Diameter.

4. At the End of this Line in the Periphery of the Primitive Circle erect a Perpendicular, cutting the first Diameter in a third Point.

5. Through the two given Points, and this third Point strike a Circle, and it shall be the great Circle required.

Example. Let it be required to draw a great Circle through the two Points f and G.



1. Through

1. Through *f* and *e* draw the Diameter of the Primitive *a b*.
2. Cross it at right Angles with the Diameter *c d*
3. Draw a Line either from *f* to *c*, or from *f* to *d*.
4. To either of which Lines *f c*, or *f d*, at the Extremity of *c* or *d*, erect the Perpendicular *c i*, intersecting the Diameter *a b*, produceth in *i* the third Point.
5. Through these three Points *f G i*, describe the Circle *f G i* by the known Problem of finding a lost Center, *Euclid* 25, 3. and 'tis done. Draw the Line K L; and if it pass through the Center of the Primitive, your Work is right, else not: Because then the required great Circle cuts the Primitive in two opposite Points.

PROP. X.

To draw a great Circle Perpendicular to a given Great Circle.

GENERAL RULE.

Draw a great Circle thro' the Pole of the given great Circle, and it will be perpendicular to a great Circle given.

Here are four Cases.

1. Perpendicular to the *Primitive Circle*.
2. A *Right Circle* perpendicular to a *Right Circle*.
3. An *Oblique Circle* perpendicular to a *Right Circle*.
4. An *Oblique Circle* perpendicular to an *Oblique Circle*.

CASE I.

To draw a Circle Perpendicular to the Primitive Circle given.

RULE.

Through the Center of the *Primitive Circle* draw a Diameter, and 'tis done: For the Center of the *Primitive Circle* is its Pole.

RULE.

CASE II.

To draw a Right Circle perpendicular to a Right Circle.

RULE.

This is done by drawing the Diameter perpendicular to the Diameter, or *Right Circle* given.

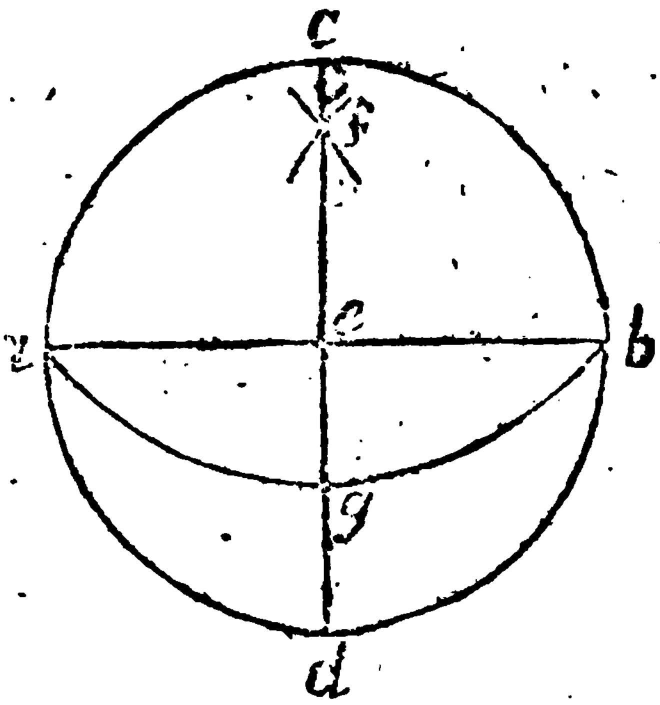
CASE III.

To draw an oblique Circle perpendicular to a Right Circle given.

RULE.

1. Find the Poles of the given *Right Circle* by *Prop.* 1. *Case* 2.
2. Draw a Circle through those two Poles.

Example. Let it be required to draw an oblique Circle perpendicular to the right Circle *c d*.



Lay the Chord of 90 from *c* to *a* and *b*, and draw the Diameter *a b*; for *a* and *b* are the Poles of the right Circles *c d*. With any distance of the Compasses set one Foot in *a* and *b*, and strike the two Arches at *f*; then is *f* the Center of the oblique Circle *a g b*; and is at right Angles with the given right Circle *c d*, as was required.

Note, That if the oblique Circle required to be drawn, were so limited as to make a given Angle with the *Primitive Circle*,

Then take the Secant of that Angle (as in *Case* 2. *Prop.* 3.) in your Compasses; and placing one Foot in *a* or *b*, make two Arches crossing each other as before at *f*; then shall *f* be the Center: Or, take the Tangent of that Angle, and set off in the right Circle *c d* from the Center *e*, to *f*, and 'tis done.

But if the Point *g* be given, through which this oblique Circle should pass without any relation to the Angle it should make with the Primitive Circle, (though that be naturally given) a Circle struck through the three Points *a g* and *b*, will answer the Demand.

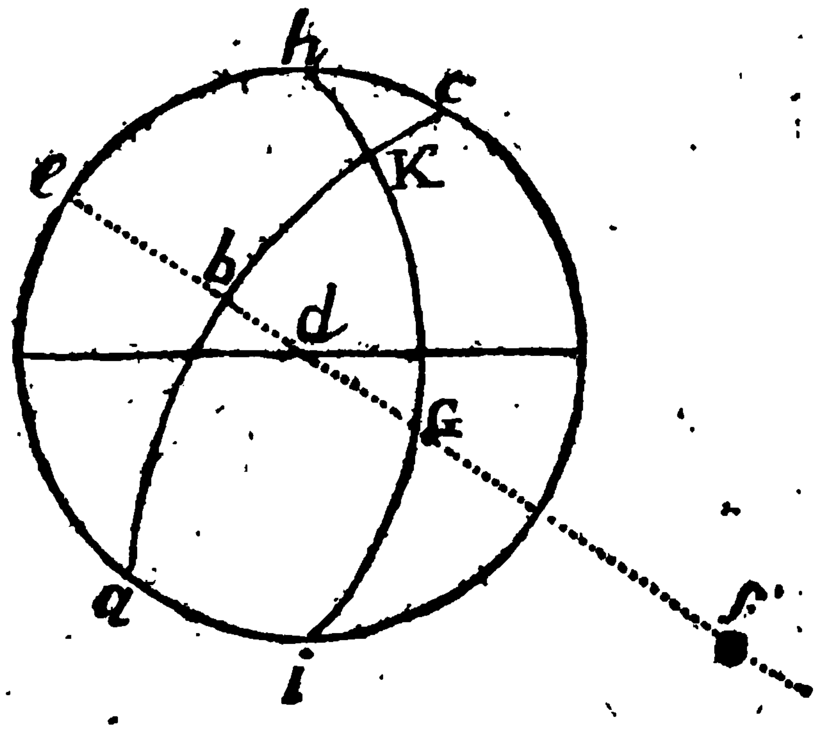
CASE IV.

To draw an Oblique Circle perpendicular to a given Oblique Circle.

RULE.

First, Find the Pole of the given *Oblique Circle* by *Prop.* 2.

2. Through that Pole draw a great Circle; or, which is the ſame, draw ſuch an Arch as may paſs through the Pole ſo found, and may interſect the *Primitive* in Points diametrically oppoſite.



Example. Let it be required to draw an oblique Circle perpendicular to the oblique Circle *a b c*. *First*, I find the Pole of the oblique Circle *a b c* to be at *G*; then I lay a Ruler over the Center *d*, of the Primitive (any wiſe, becauſe it muſt cut the Primitive in oppoſite Points) cutting it in *h* and *i*; find the Center that will ſweep the three Points *i G h*, and it ſhall be the Center of the great Circle required, and cuts the great oblique Circle *a b c* at right Angles at K. *Note*, If the Point K in the Circle *a b c* be given, then draw a great Circle through the two Points *G* and K by the 8th *Prop.* And if it be required that the Circle *i G h*, ſhould make any given Angle, it may be done by the 7th *Propoſition*.

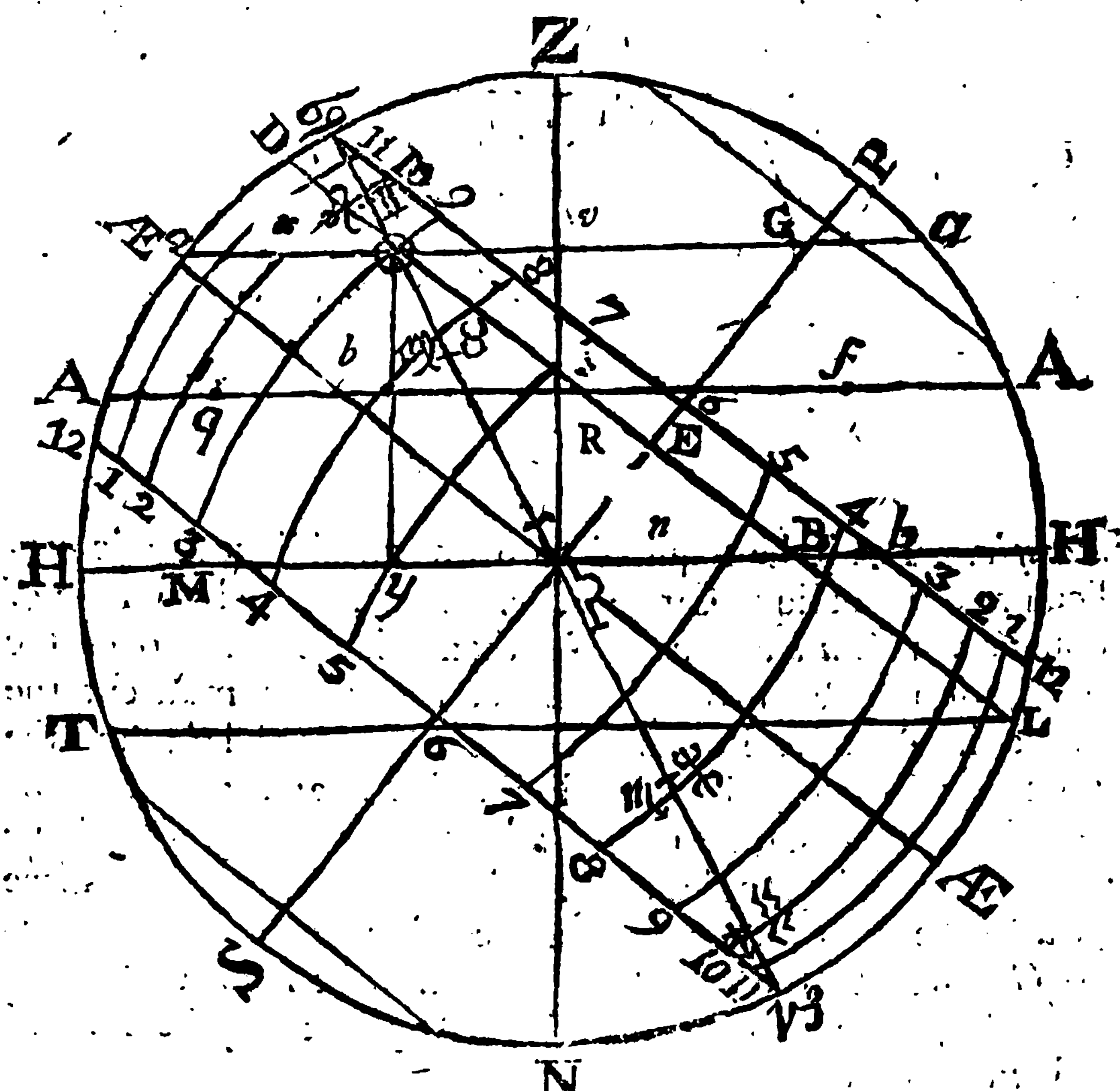
SECTION III.

The Projection of the Sphere Orthographically and Stereographically, on the Planes of the Meridian, Ecliptic, and Horizon.

PROB. I.

To Project the Sphere Orthographically on the Plane of the Meridian.

TAKE any convenient Radius from the Chord of 60 Deg. on the Sector, and ſweep the primitive Circle, which doth always repreſent the Meridian of the Place projected upon the Solſtitial Colure. Draw H H for the Horizon, and Z N for



the

the east and west Azimuths, Z the Zenith, and N the Nadir of the Place; take the Chord of the proposed Latitude (as suppose 51° 32′) and set it from H to P, and from Z to Æ, draw P S for the Earth's Axis, and Æ Æ for the Equinoctial: Take the Chord of 23° 29′, the distance of the Tropics from the Equinoctial, and set it from Æ on the Meridian each way, and draw ♋ 12, and ♑ 12, parallel to the Equinoctial: Also set the same Chord of 23° 29′ on the Meridian from the Poles at P and S, each way, and draw the Polar Circles parallel to the Equinoctial: Take the Chord of 18° and set it from H to T and L under the Horizon, which shall be the Parallel of Twilight. Draw ♋, ♑ for the Ecliptic, and on it from the Center of the primitive Circle set the Sines of 30° and 60° each way, and place the Signs of the Zodiac, ♈ and ♎ to fall in the Center, and ♋ and ♑ at the Circumference: A A and *a a* are Parallels of Altitude; the first being drawn by the Chord of 20 Deg. and the other of 40; the Meridian or Hour-Circles I have only drawn from Tropic to Tropic, which if they were continued, would meet in the Poles, and are Ellipses, and are drawn, as I shall now shew in the Azimuths.

First, Draw as many Parallels of Altitude as you please; as here I have drawn one at 20, and another at 40 Deg. (the more the better;) then take the Sine of what Azimuths you design to project, from the Radius of the primitive Circle, and set it from the Center on the Horizon; as here I would draw the 45th and 11th Azimuths from the East or West. I set them off severally to *m* and *n*; these are the Points in the Horizon thro' which the said Azimuths must pass: But to find the Points in the Parallels of Altitude through which they must pass, take half the Parallel of Altitude, and make it the Radius of the Line of Sines on the Sector = R A; from it take the Sine of 45° and set it from R to *q* on the Parallel; also make *a v* the Radius of the Line of Sines on the Sector, and take from it the Sine of 45° the required Azimuths, and set it on the Parallel from *v* to *x*; so are the Points *x q* and *m*, the Points through which the 45th Azimuth must pass. Thus you must find Points under the Horizon, and by an even Hand draw the Elliptical Azimuths, which will all meet in the Zenith and Nadir. And after the same manner are the Hour-Circles or Meridian drawn, by first drawing as many Parallels to the Equinoctial as you please towards the Poles; and by finding Points, as has been shewn in the Azimuths, first marking them in the Equinoctial by the Sines of 15, 30, 45, 60 and 75°. The Projection being finished,

we will suppose the Sun in 10° ♉ or 20 ♌: (For then the Declination is the same, *viz.* 14° 50′ 28″ N.) Draw D L, by setting off the Chord of the Declination, which shall represent the Parallel of the Sun's Declination for those Days; Then

will	♈ ☉	be the	Longitude.
	B		Rising or Setting.
	B E		Ascen. Difference.
	F		Time ☉ is due East and West.
	Y ☉		Altitude a little before 9 o'Clock,
	Æ D =		Declination.
	♈ *b*		Right Ascension.
	B D		Semidiurnal Ark.
	B L		Seminocturnal Ark.
	♈ B		Amplitude.

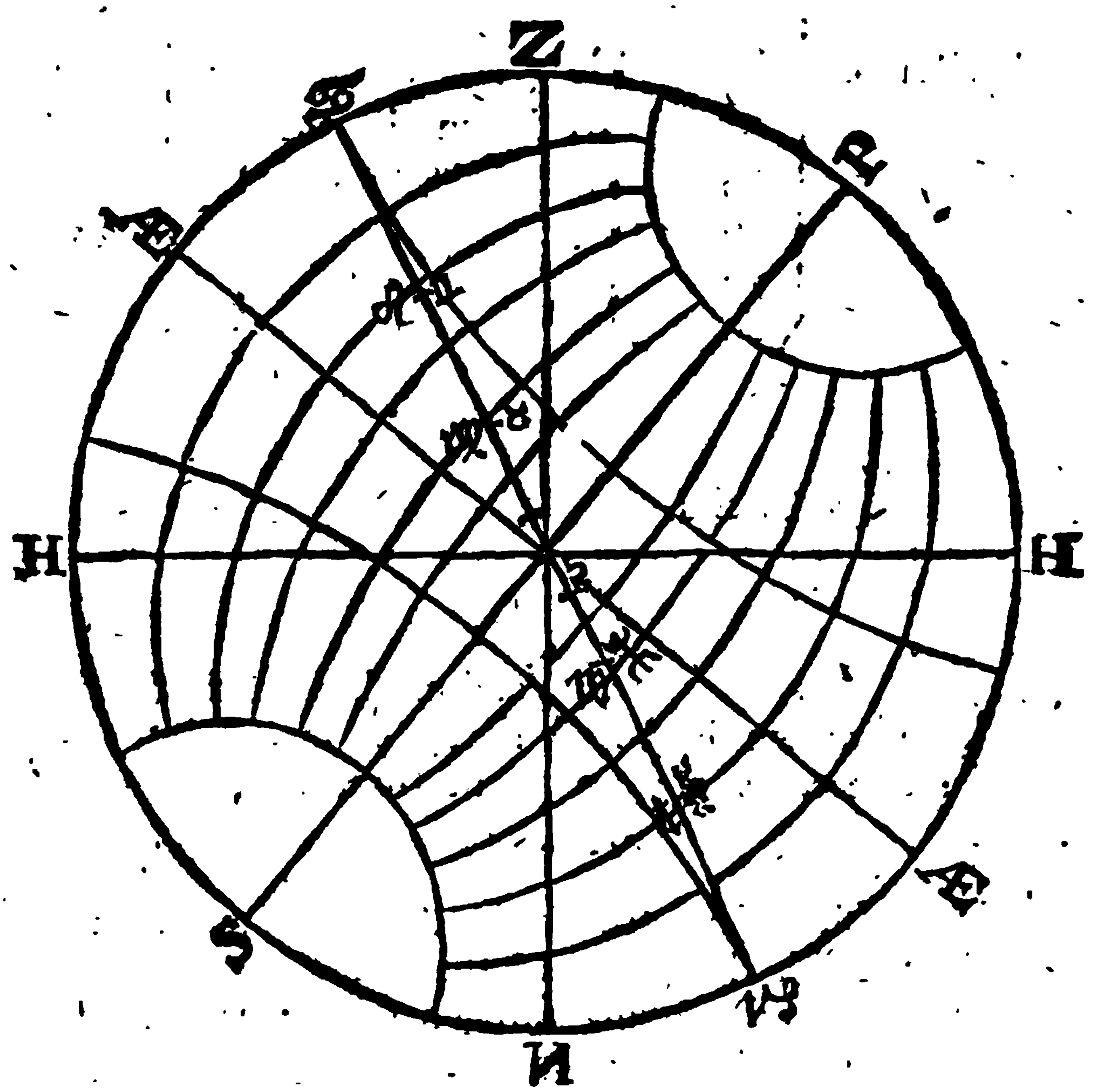
To him that understands how to lay down an Ellipsis by the Line of Sines, the Method of projecting this will become exceeding easy. This Projection I have contrived on Brass, so that the Body of the Work moves within the Graduated Meridian to any Latitude; and upon it I have a moveable Horizon with two Sights to take the Sun's Altitude, by which it becomes an Universal Dial, and is of excellent use for Sea-faring Men to find their Latitude and Hour of the Day: For having the Sun's Zenith-Distance, (as suppose 20 Deg. to the Northward) on the 6th Day of *July*, the Sun's Declination 21 Deg. 19′ N. with your Pen mark on the Meridian the Sun's Declination, and move the Projection till that Point touch 20°, the Zenith-Distance, and then doth the north Pole of the Projection cut the Meridian at 1 Deg. 19 Min. above the Horizon, and such is the Latitude of that Place of Observation North. Here the Work by the Pen is not only saved, but also demonstrated.

PROB. II.

PROB. II.

To Project the Sphere Stereographically upon the Plane of the Meridian.

With the Chord of 60 Degrees sweep the primitive Circles, draw H H for the Horizon, and z N for the East and West Azimuth, z the Zenith of your Habitation, and N the Nadir. Take 51 Degrees 32 Minutes, the Latitude from the Line of Chords, and set it from H to P, and from z to Æ, draw P S for the Axis, and Æ Æ for the Equinoctial; take the Chord



of 23 Degrees 29 Minutes, and set off the Tropics and Polar Circles as in the last Projection. *Note*, the Tropics and all Parallels of Declination, *&c.* Hours, Circles, Azimuths, and Almicanthers

Almicanters are drawn by the Tangents of the Angles that they form with the Periphery of the Plane of the Projection: For as in the Orthographic Projection they were all Ellipses, here they are Circles: Then to draw the Tropics; because they are 66 Degrees, 31 Min. Distant from the Pole set one Foot in the Axis (being supposed to be continued) and draw the Tropics. Or if the Secants of the several Distances from the nearest Pole, be set off in the Axis from ♈, the Center of the Projection on the same side of the Equinoctial as they lye, you will have their several Centers; and the Tangent of the same Distance will be their Radii, or Semidiameter. Therefore the

	°	′		°	′
Parallel of	10		is drawn by the Tangent of	80	
	20			70	
	23	29		66	31
	30			60	
	40			50	
	50			40	
	60			30	
	66	31		23	29
	70			20	
	80			10	

And the Hour-Circles

			°		°
of	1	are drawn by the Secants of	15	and marked in the Equinoctial by their half Tangent from ♈, of	75
	2		30		60
	3		45		45
	4		60		30
	5		75		15

The Hour-Line of 6 is the Earth's Axis; therefore a straight Line passes through the Center of the Projection.

All the great Circles passing through the Center are divided by the Line of Semi-Tangents of their several Divisions from ♈. So the Ecliptic is divided by opening the Sector to the Radius of the primitive Circle; and because every Sign is 30 Degrees, take the Tangents of 15 Degrees, 30 Degrees, severally, and they will mark out the Places of ♉, ♍, ♊, ♌, on one side, and ♏, ♓, ♐, ♒, on the other side, ♋ and

♋ and ♑ do fall at the Periphery 90 Degrees from ♈ and ♎, whose Semi-Tangent is 45 Degrees = to the Radius of the Projection. Almicanthers, or Parallels of Altitude in this Projection; as also Parallels of Celestial Latitude are drawn as the Parallels of Declination; only the Centers of the first fall in the prime Vertical; but in the latter, in the Axis of the Ecliptic.

In the following Problems of the Sphere I shall always make use of the Stereographic Projection. It is the common Method used by most Authors to project this in a parallel Position; and by drawing the Horizon of any particular Place, they fixt it for that Latitude: But I have chosen rather an oblique Position, and have adapted the Pole to the Elevation of *London*. I shall leave it to the Reader's choice to do what way he fancies best; for the distance from St *Paul's* to the *Royal-Exchange* is the same, as from the *Royal Exchange* to St *Paul's*.

PROB. III.

The Stereographic Projection of the Sphere upon the Plane of the Ecliptic.

This is what I call the *Copernican Projection of the Globe*; because by it we solve the *Phænomena* of the Heavens according to the Earth's Motion. At any convenient Radius sweep the Circle, which shall here represent the Orbit of the Earth, and quarter it; so shall ♈ ♎ represent the Equinoctial Colure, and ♋ ♑ the Solstitial; their Intersection being the Pole of the Ecliptic at E. Take the Semi-Tangent of 23° 29′ the constant Distance of the two Poles, and set on the Solstitial Colure

from

from E to P, and that is the North Pole of the Globe. Divide each Quarter of the Ecliptic into three equal Parts, and place the rest of the Signs in their order, as you see done in the Figure.

Take the Tangent Complement of the Distance of the two Poles 66° 31′ and set one Foot in E, the other will give the Center of the first Meridian, *viz.* ♒ P ♎ in the Solstitial Colure continued: Through that Center, and at Right Angles to the Colure, draw an occult Line, and set off the Tangent of 15, 30, 45, 60, and 75°, which are the Centers of the other Meridian. Then to draw the Path of any Vertex observe for *London*, thus: Add the Co. Lat. 38° 28′ to the Distance of the two Poles 23° 29′, their Sum 61° 57′; set by the Semi-Tangents from E to A, and 38° 28′—23° 29′ = 14° 59′; set the Semi-Tangents thereof from E to B; bissect A B in C; so is C the Center of the Vertex of *London*. Now, suppose the Earth in ♒, then will the Sun appear in ♌; draw ♌ E ♒, and continue it till it meet with the former Occult Line, and that will be the Center of 6 P 6; draw ♉ E ♏ at right Angles to the place of the Sun and Earth, and that shall be the Horizon of the Disk; and continue it till it meet the former Occult Line, and that Intersection shall be the Center of ♌ P ♒, which is the proper Meridian to the place of the Earth and Sun that Day.

All that part which lies between the Horizon of the Disk ♉ E ♏, and the Place of the Earth ♒, is in Darkness, as is represented by the shady part: The North Pole is now illuminated, and the Day is more than 12 Hours long, which

is

is shewed by the Path of the Vertex of *London*, cutting the 6 o'Clock Hour-Line before 6 in the Morning, and after 6 at Night. You may project several Paths in one Scheme, and by a moveable Horizon of the Earth's Disk (which I have contrived) you may see at one View what places are illuminated and what are not: For the Horizon of the Disk moving upon the Pole of the Ecliptic, determines the Quantity of Light and Darkness. So when the Earth comes into ♋, the North Pole of the Globe is then in Darkness; but coming to ♈ or ♎, the North Pole lies in the Horizon of the Disk, and consequently there is an equal share of Day and Night all over the Globe. This is the necessary result of the two Motions of the Earth; that is, round its Axis, and its annual one; and there needs no third Motion be feigned to explain it, or to account for it. For as the Earth moves annually round the Sun, without the diurnal Motion, it moves only according to its Center of Gravity; and each Point and Line in it always keep the same Position. Let its Axis be one of those Lines; the diurnal Revolution of the Earth round this, which as to that Motion is supposed immoveable, cannot change the Position of, and therefore it will be always the same, *i. e.* always Parallel to itself.

PROB. IV.

The Stereographic Projection of the Sphere on the Plane of the Horizon.

With the Chord of 60 Degrees sweep the primitive Circle, which in this Projection represents the Horizon of our Habitation.

Cross it with two Diameters at right Angles, so shall 12 z 12 be the Meridian, and 6 z 6 the prime Vertical, or Azimuth of East and West, and z will be the Zenith of the Place.

Then because the Zenith of any Place is distant from the Pole equal to the Complement of the Latitude, take therefore the Semi-Tangent of 38 Deg. 28 Min. and set it on the Meridian from z to P; so shall P be the north Pole of the World in this Projection: Because the Latitude is equal to the distance from the Zenith to the Equinoctial, take the

O Tangent

Tangent of half the Latitude 51 Degrees 32 Minutes, viz. 25 Deg. 46 Min. and set it from z to Æ, and the Secant of 38 Deg. 28 Min. from Æ to O, or the Tangent of it from z to O, will give the Point O, the Center of the Equinoctial.

Take the Tangent of the given Latitude 51 Degr. 32 Min, and set it on the Meridian from P to C, and draw the six-a-clock Hour-circle 6 P 6. Draw A B at right Angles to the Meridian through C, open the Sector to the Radius P C, and take off the Tangent of 15, 30, 45, 60, and 75 Degrees, and set them off from C towards A and B, and they shall be the Centers of the other Hour-circles, as you see in the Projection are drawn.

A B

60 45 30 15 C 15 30 45 60

In this Projection, Almicanthers are all parallel to the primitive Circle.

And Azimuths are all right Lines passing through z, the Zenith, to equal Divisions in the Horizon; but omitted to avoid Confusion.

Parallels of Declination are all lesser Circles, and parallel to the Equinoctial; and their Intersections with the Meridian are found setting the half Tangent of their Distance from the Zenith, Southward, and Northward: Their Centers are found by bissecting the Distance between those two Points.

Thus;

Thus: For the Tropics Latitude, *London.*

	°	′			°	′
Height Equinoctial	38	28	or	thus	51	32
Obliquity Ecliptic	23	29		Sub.	23	29
Meridian Altitude	61	57		Rem.	28	3
Zenith — — —	90	0				

Tropic ♋ from Zenith 28 3 to the Southward.

Then because the Tropic of ♋ is just so much depressed below the Horizon on the Meridian to the North, as much as the Tropic of ♑ is elevated to the South, 14 Degrees, 59 Minutes; to this 14 Degr. 59 Min. add the Quadrant, or distance of the Zenith from the Horizon, and the Sum is 104° 59′: Take the half Tangent thereof, *viz.* 52° 29′ ½, and set it on the Meridian from Z to E; bissect E in C; so shall C be the Center of the Tropic of *Cancer*. Or, because the greatest Amplitude in the given Latitude is nearly 39° 52′ North and South, take the Chord thereof, and set it from 6 to 6, either way towards 12, 12, upon the Horizon to ♈ ♈ for ♋; and *a*, *a*, for ♑; find, the Centers that will sweep these Points severally, and that will draw the Tropics.

Secondly, For the Tropic of *Capricorn*:

	°	′		°	′	
	38	28	or thus	51	32	
	23	29		23	29	
Z Sub.	14	59		75	1	♑ from Z South.
from	90	0		37	30 ½	Tang. from Z.
♑ from Z	75	1				

	Deg.	*Min.*	
To a Quadrant ——	90	0	
Add Depression	61	57	
♑ from Z to the North	151	57	
Half — —	75	58 ½	Tang. from Z.

Take the Tangent of 75, 58, and set it on the Meridian from Z, beyond E Northward: Take the Tangent of 37

Degrees 30 Minutes, and set it from Z to ♑ Southward; divide these two Points into two equal parts, and that shall give the Center of the Tropic of *Capricorn* a ♑ at Or, draw it by its Amplitude, as directed in the other Tropic. And if you would draw the Parallels of every 5 Degrees of Declination, and the Parallels of the beginning of each Sign North, they may be done by this Table. Latitude *London.*

°	′	″	°	′	″	°	′	″	°	′	″	°	′	″
0	0	0	51	32	0	25	46	0	128	28	0	64	14	0
5	0	0	46	32	0	23	16	0	123	28	0	61	44	0
10	0	0	41	32	0	20	46	0	118	28	0	59	14	0
11	29	33	40	2	27	20	1	13½	116	58	27	58	29	13½
15	0	0	36	32		18	16	0	113	28	0	56	44	0
20	0	0	31	32		15	46	0	108	28	0	54	14	0
20	11	15	31	20	45	15	40	22	108	17	45	54	8	52
23	29		28	3		14	3	½	104	59	0	52	27	3

The Column to the left Hand shews the Degrees of Declination, including the Equinoctial and Tropic of *Cancer*. The second Column, the Distance of each Parallel from the Zenith of *London*. In the Third are the half Tangents to be set off in the Projection from Z on the Meridian, to the South. In the fourth Column is the Distance of Declination from the Zenith to the North. The fifth and last Column contains the half Tangents to be set on the Meridian from Z Northward. The midway between the North and South Intersection on each Parallel with the Meridian shews the Centers in the Projection to draw each Parallel by.

The

The Parallels of south Declination must be drawn by this Table for Lat. 51 Degr. 32 Min. N.

°	′	″	°	′	″	°	′	″	°	′	″	°	′	″
0	0		51	32		25	46		128	28		64	14	
5	0		56	32		28	16		133	28		66	44	
10	0		61	32		30	46		138	28		69	14	
11	29	33	63	1	33	31	30	46	139	57	33	69	58	46½
15	0		66	32		33	16		143	28		71	44	
20	0		71	32		35	46		148	39	15	74	14	
20	11	15	71	43	15	35	51	37	151	57		74	19	37
23	29		75	1		37	30	½				75	58	30

The Title of each Column is the same with those above described; only these are for south Parallel of Declinations, and the other were for north.

To draw the Ecliptic.

This, you see, is two Halfs, *viz.* North and South, and marked with their proper Signs. Because the greatest Meridian Altitude of the northern Part of the Ecliptic is 61 Deg. 57 Min. at *London*, take the Secant of 61 Deg. 57 Min. and set it on the Meridian from ♋, where the Tropic intersects it northward beyond E, shall give the Center of the part marked with ♈, ♉, ♊, ♋, ♌, ♍. And because the least Meridian Altitude of the southern Part in the given Latitude is 14 Deg. 59 Min. take the Secant thereof, and set one Foot in your Compasses in the Intersection of the Tropic of *Capricorn* with the Meridian at ♑, and the other Foot will give the Point D, the Center of the Ecliptic marked with ♎, ♏, ♐, ♑, ♒, ♓.

To lay the Signs down on the Ecliptic.

See what Declination the beginning of each Sign has, which are as is here set down.

	Deg.	*Min.*	*Sec.*				*Deg.*	*Min.*	*Sec.*	
♈	0	0	0	North.	And	♎	0	0	0	South.
♉ ♍	11	29	33			♏ ♓	11	29	33	
♊ ♌	20	11	15			♐ ♒	20	11	15	
♋	23	29	0			♑	23	29	0	

Whose

Whose half Tangents you have in the foregoing Tables for drawing the Parallels; and according to those Directions if you draw these Parallels of Declination of the beginning of each Sign, where they intersect the Ecliptic, they are the Places where you are to write the Signs as you see in the Projection.

Secondly, The Ecliptic may be divided by first finding the Poles of each part of the Ecliptic; then lay a Ruler to each Pole severally, and to 30 and 60 Degrees in the primitive Circle, and that will truly divide each Half of the Ecliptic as before.

Note, In all Stereographic Projections all Diameters are measured on the Scale of half Tangents; the reason of which you have in the Spheric Geometry, with which be sure to acquaint your self well before you proceed to the Projection of the Sphere. And this is the Ground of all Dialing; or the true Projection of the Hour-circles of the Sphere on any given Plane.

And if to this Projection there be fitted a Label or Index to move upon the Center, and its Edge divided by the Line of half Tangents, and numbered with 10, 20, 30, 40, 50, 60, 70, 80, 90, from the Circumference to the Center, it will then be fitly accommodated to perform many Conclusions of the Sphere. As for Instance, in Dialing: Let straight Lines be drawn from the Center of the Horizon where the Hour Hour-circles intersect it, and they shall be the true Hour-lines of an Horizontal Dial for the Latitude the Projection was made. The Degrees and Minutes answering each Hour and Quarter in the Limb of the Horizon are as is here set down.

And if at any time you have a mind to make an Horizontal Dial for the Latitude of *London*, take these Degrees and Minutes from the Line of Chords, and set them on the Horizon from the Meridian each way, and they will mark out the Hour-lines of an Horizontal Dial.

Hour	°	'	Hour	°	'
12	0	0	3	34	28
1	2	56	3	38	3
2	5	52	1	41	45
3	8	51	2	45	34
I	11	51	3	49	30
1	14	52	4	53	35
2	17	57	1	57	47
3	21	6	2	62	6
2	24	20	3	66	33
1	27	36	5	71	6
2	31	0			

2. For

2. For an erect direct North or South Dial. Lay the Graduated Index before described upon the Line 6, z 6, and the Hour-circles will cut the Index in the Number of Degrees and Minutes of every Hour and Quarter, as is set down in the following Table.

H	°	'
1	75	45
2	80	25
3	85	13
6	90	00

These Degrees and Minutes may by help of the Line of Chords be projected into erect direct North and South Planes, setting them off from the Meridian each way.

3. For a Vertical declining Dial. Let the Declination be 30 to the West. Lay the Index to the Plane's Declination in the Limb, or primitive Circle, and the Hour-lines in the Projection will cut the Index in the Degrees and Minutes that they will have upon the Plane. In these Places you must begin to Number the Index at the Center with 10, 20, &c.

4. For direct inclining Planes. By Spheric Geometry, project the oblique Circles representing the inclining Plane, and find its Pole, a Ruler being laid to its Pole, and to the several Points where the Hour-circles in the Projection cross the Plane; the Ruler will cut the Degrees in the Horizon that the Hour-lines must have upon such an inclining Plane.

Lastly, For declining inclining Planes. This Plane being projected, and its Pole found, a Ruler laid to its Pole, and the Intersections of the Plane, with the Hour-circles, shall give in the Primitive the Degrees of the distance that the respective Hour-lines must have upon that Plane. See my *Mechanic Dialling*, lately published.

H.	°	'
12	0	0
1	2	20
2	4	41
3	7	3
I	9	28
1	11	56
2	14	27
3	17	4
2	19	45
1	22	35
2	25	32
3	28	38
3	31	54
1	35	22
2	39	3
3	42	58
4	47	9
1	51	36
2	56	20
3	61	23
5	66	42
1	72	17
2	78	3
3	83	59
6	90	0

The *Gnomon* of all Dials must stand parallel to the Earth's Axis; and in *the Doctrine of the Sphere* I shall shew the reason of the Analogies for calculating Hour-lines on all sorts of Planes, for any Place of the World.

SECT

SECTION IV.

The Doctrine of the Sphere.

BY the *Doctrine of the Sphere*, is meant, the Solution of such Problems as relate to the Heavens, or Concavity of the visible World: In measuring the Circles thereof, the Angles they make with each other, I shall shew in a Method more concise and methodical than any has done hitherto. For Spheric Geometry, see my *Young Mathematician's Companion*. I have told you in several Places of the *Astronomical Definitions*, that the Obliquity of the Ecliptic is fixed at 23 Deg. 29 Min. which you must carefully remember; and which was determined thus:

	Deg.	Min.
At the *Tower* of *London* the Height of the North Pole is exactly ——— ———	51	32
When Sun enters ♋, his Merid. Altit. is there ———	61	57
When Sun enters ♑, his Meridian Altitude is there: Sub. ——— ———	14	59
Difference of Meridian Altitudes ———	46	58
Half, is the Obliquity of the Ecliptic, or Distance of the Pole of the Equinoctial from the Pole of the Ecliptic = to Sun's greatest Declination ——	23	29

And here I shall annex the Names of the Ancient Astronomers, and the Times when they flourished, who have observed the Obliquity of the Ecliptic, and its Quantity.

		°	′	″
Before Christ.				
280	*Aristarchus*	23	51	00
270	*Eratosthenes*	23	51	00
140	*Hipparchus*	23	51	00
After Christ.				
140	*Ptolemy*	23	51	20
825	*Benimula*	23	35	00
827	*Almamon*	23	35	00
828	*Jabia Ebn Abumansar*	23	35	00

882

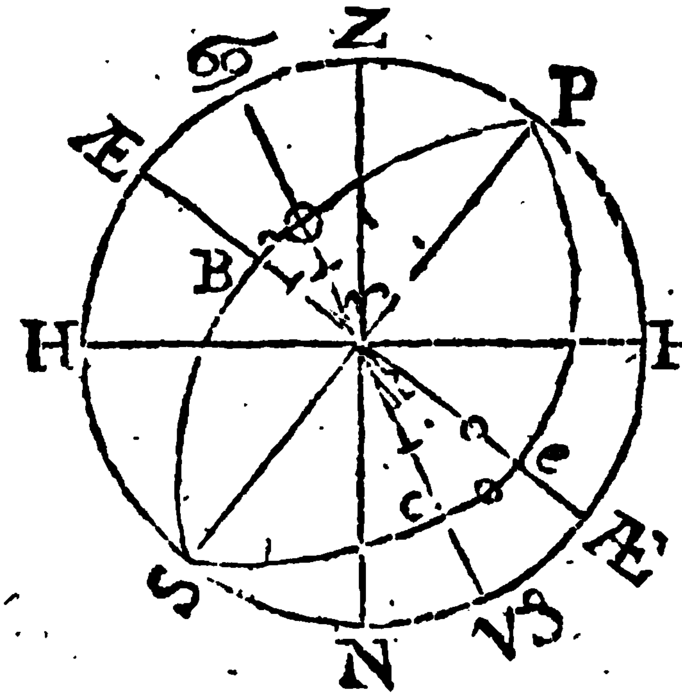
	°	′	″
880 *Mahumed Eben Gaber*	23	35	00
911 *Ababet Eben Corra*	23	33	30
992 *Abu Mahumed Al Cagandi*	23	22	21
1269 *Cojah Nasiroddni*	23	30	00
1363 *Eben Shatir*	23	31	00
1437 *Uleg Fieg*	23	30	17
1460 *Regiomontanus*	23	29	00
1490 *Dominicus Maria Novaras Ferrariensis*	23	29	00
1514 *Vernerus*	23	28	00
1572 *Tycho Brahe*	23	31	30
1670 *Hevelius*	23	30	20
1670 *P. Mengoli*	23	28	24
1673 Mr *Flamsteed*	23	29	00

The Reader from this must not conclude that the Obliquity of the Ecliptic has altered, but that the different Determinations of it have arisen from the badness of the Observations, and a want of a true Knowledge of the Parallaxes and Refractions of the Heavenly Bodies. See Philosophical Transactions, Numb. 163. and *Marcus Manilius.*

PROBLEM I.

The Sun's greatest Declination being 23 Deg. 29 Min. and his Place given, to find his present Declination.

Example 1728, *April* 29, at Noon, Sun's true Place by our Tables is ♉ 19 Deg. 55 Min. 58 Sec. I demand his true Declination.



In the right Angle Spheric Triangle ♈ B ☉, right Angled at B, are given, ♈ ☉ the Sun's distance from the next Equinoctial Point ♈ 49 Deg. 55 Min. 58 Sec. with the Angle B ♈ ☉ 23 Deg. 29 Min. to find B ☉ the present Declination.

P

	°	′	″	
As Radius	90	00	00	10.000000
To Sine ♈ ☉ Longitude	49	55	58	9.883825
So Sine *Angle* B ♈ ☉, Obliquity	23	29	00	9.600409
To Sine B ☉ Declination N.	17	45	19	9.484234

Note, If the Sun be entering ♐ or ♒, that is, 60° from the Equinoctial Points represented in the Rect-angled Spherical Triangle by ♎ *c*, *e*, the Declination *c e* will be found to be 20° 11′ 15″ South.

PROB. II.

The Sun's present and greatest Declination given, to find his Longitude or Place in the Ecliptic.

This is the Converse of the last Problem, but of singular use in Astronomical Observations, as I shall shew in its proper Place.

Example. In the last Diagram let *Angle* B ♈ ☉, and B ☉ be given, to find ♈ ☉, the Analogy is,

	°	′	″	
As Sine *Angle* B ♈ ☉, obliquity Ecliptic	23	29	00	9.600409
To Sine B ☉, present Declination N.	17	45	19	9.484234
So Radius	90	00	00	10.000000
To Sine ♈ ☉ Longitude from ♈.	49	55	58	9.883825

That is in ♉ 19° 55′ 58″, because Declination was N. and from ♈.

I hope I need not acquaint my Reader that having any two things given in a right Angled Spherical Triangle, the third may easily be found, pre-supposing him well acquainted with Trigonometry before he meddles with this Section.

PROB.

PROB. III.

Given the Sun's Place and greatest Declination to find his Right Ascension.

Example, April 29th Day at Noon 1728, I demand the Sun's R. A. his Longitude being as in the preceeding Scheme.

ANALOGY.

	Deg.	*Min.*	*Sec.*	
As C. t. ♈ ☉ Longitude	49	55	58	— 9.924848
To Radius	90	00	00	—10.000000
So. Co. Sine *Angle* B ♈ ☉	23	29	00	— 9.962453
To t. ♈ B. R. Ascension	47	28	39	—10.037605

Or, by Transposition, say,

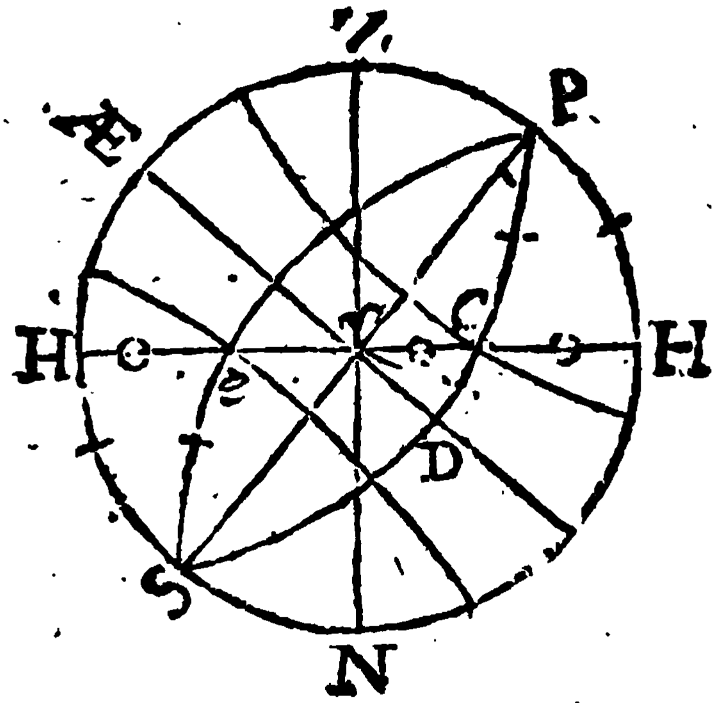
	Deg.	*Min.*	*Sec.*	
As Radius	90	00	00	—10.000000
To t. ♈ ☉	49	55	58	—10.075151
So C. S. *Angle* B ♈ ☉	23	29	00	— 9.962451
To t. ♈ B. R. A.	47	28	39	—10.037604

Note, If the Sun be in the first Quadrant of the Ecliptic ♈, ♉, ♊, as in the Example above, then the fourth proportional Arch is the Sun's right Ascension from *Aries*; but if the Sun be in the second Quadrant ♋, ♌, ♍, then you must subtract the fourth proportional Arch from 180 Degrees, and the Remainder is the right Ascension from ♈. When the Sun is in the third Quadrant ♎, ♏, ♐, you must add the fourth proportional Arch (found as above) to 180, and that Sum is the Sun's right Ascension from ♈. *Lastly*, When the Sun is in the last Quadrant of the Ecliptic ♑, ♒, ♓, then subtract the fourth proportional Arch from 360 Degrees, and the Remainder is the Sun's right Ascension from ♈. So if the Sun be 0° ♐, you will find his R. A. by the preceeding Method in the Triangle ♎ ς *e*, to be 237° 48′ 36″. And when he is in the very beginning of ♒, his right Ascension is 302° 11′ 24″.

PROB. IV.

Given, the Latitude of the Place, and the Sun's Declination, to find his Amplitude.

Example. *Anno* 1728, *April* 29th Day at Noon, the Sun's Declination was found by *Prop.* 1. to be 17 Deg. 45 Min. 19 Sec. I demand his Amplitude of rising and setting at *London.*



In the adjacent Scheme, and right Angled Spherical Triangle P H C, are given H P, the Latitude of the Place, and P C the Complement of the Declination, or Sun's distance from the North Pole, to find C H, the Amplitude from the North, whose Complement ♈ C is the Amplitude from the east and west Point of the Horizon.

ANALOGY.

	Deg.	Min.	Sec.	
As C. S. of H P the Latitude	51	32	00—	9.793832
To Radius	90	00	00—	10.000000
So Sine ☉ Declination North	17	45	19—	9.484231
To Sine ♈ C, the Sun's Amplitude	29	21	21—	9.690399

Or the same may more rationally be found in the Triangle ♈ D C, in which are given, the Angle D ♈ C = 38 Deg. 28 Min. the Complement of the Latitude of *London*, and D C the Sun's Declination North, to find ♈ C the Sun's Amplitude, from the east and west Points of the Horizon.

ANA-

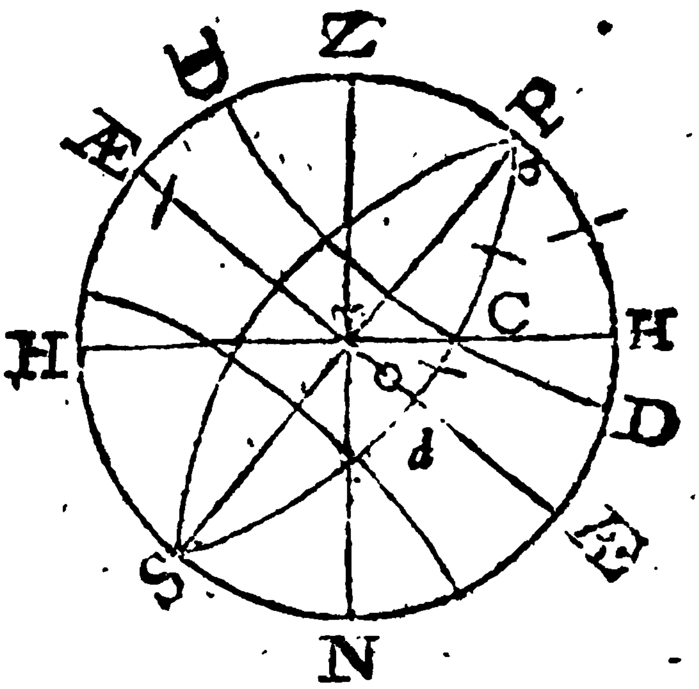
ANALOGY.

	Deg.	Min.	Sec.	
As C. S. Latitude = *Angle* D ♈ C	51	32	00 —	9.793832
To Sine Sun's Declination North	17	45	19 —	9.484231
So Radius, or Sine of the Angle ♈ D C	90	00	00 —	10.000000
To Sine ♈ C, the Amplitude, North	29	21	21 —	9.690399

PROB. V.

Given, the Latitude of the Place, and the Sun's Declination, to find the Ascensional Difference, and consequently the true Time of the Sun's Rising and Setting, with the Length of the Days and Nights.

Example. Let the Sun be in the first Scruple of ♋ or ♑, and Latitude of *London*, what's the Ascensional difference?



In the right Angled Spheric Triangle C H P, there are given H P, the Latitude of *London* 51° 32′, and C P, the Complement of the Sun's Declination 66° 31′, to find the Angle C P H, the Complement of the Ascensional Difference. But it is better solved in the Triangle *d* C, in which are given the Angle *d* ♈ *C*, Co. Lat. 38° 28′ and 23° 29′ = *d C* the Sun's Declination, to find ♈ *d*, the Time in the Equinoctial from the Sun's rising or setting to 6 o'Clock.

ANA-

ANALOGY.

	Deg.	Min.	Sec.	
As Radius	90	00	00	10.000000
To T. Latitude	51	32	00	10.099913
So T. Declination	23	29	00	9.637956
To S. ♈ *d*, Asc. Diff.	33	9	04	9.737869

This 33° 9ʹ 4ʹʹ converted into Time by the Table for that purpose, will stand thus:

		h.	ʹ	ʹʹ	ʹʹʹ
	30=	2	00	00	00
	3=	0	12	00	00
	9=	0	00	36	00
	4=	0	00	00	16
Sum, sub. and add		2	12	36	16
		6	00	00	00
Sun rises at		3	47	23	44
Sun sets at		8	12	36	16

Double the Time of the Sun-rising, gives the Length of Night; and the time of the Sun's setting double, gives the Length of the Day. And as the time of Sun rising and setting are the Complement of each other to 12 Hours; so are the Length of the Day and Night the Complement of each other to 24 Hours. The time of the Sun's rising in northern Signs, is the time of his setting in southern Signs; and the time of his setting in northern Signs, is the time of his rising in southern Signs, & *contra*. For instance; the Sun rises truly at 3 h. 47ʹ 23ʹʹ 44ʹʹʹ when he touches the Tropic of ♋, which is the Time of his setting when he is in the Tropic of ♑. Also the Sun sets at 8 h. 12ʹ 36ʹʹ 16ʹʹʹ when in *Capricorn*; as you may the better be informed by the Tables of the Sun's rising and setting for all the most eminent Cities in the World, which you will find at the End of this Section.

PROB.

PROB. VI.

Given the Right Ascension, and Ascensional Difference, to find the Oblique Ascension and Oblique Descension.

In North Latitudes.

RULE.

If the Declination be			
North	sub.	Asc. Diff. from R. A.	Gives Ob. Asc.
	add	Asc. Diff. to R. A.	Gives Ob. Desc.
South	add	Asc. Diff. to R. A.	Gives Ob. Asc.
	sub.	Asc. Diff. from R. A.	Gives Ob. Desc.

In South Latitudes just the contrary.

Example. Let the right Ascension of the Sun be 47 Degr. 28 Min. 50 Sec. and Asc. Difference 23 Degr. 46 Min. 5 Sec. in the Latitude of *London*, with N. Declination. What's the Ob. Asc. and Ob. Descension?

OPERATION.

	Deg.	*Min.*	*Sec.*
Right Ascension	47	28	50
Asc. Diff. Sub. and add	23	46	5
Rem. the Ob. Ascen.	23	42	45
Sum is Ob. Descension	71	14	55

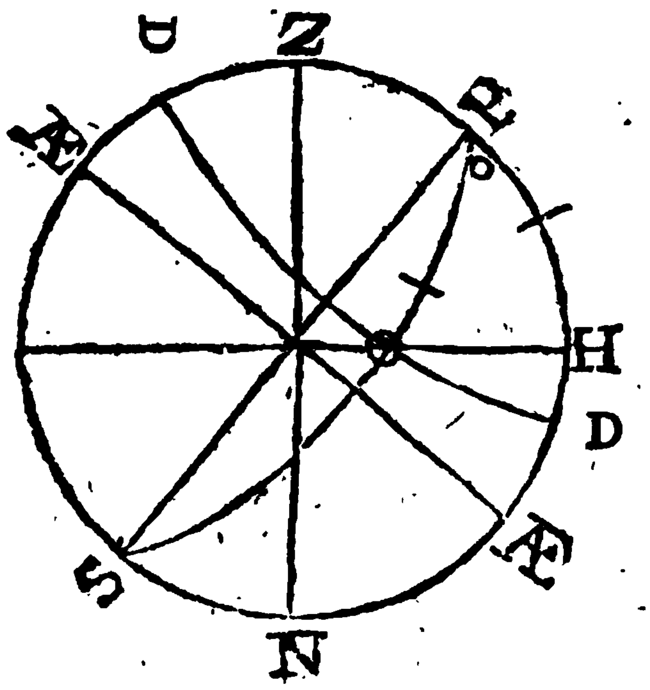
In things of this Nature we always suppose the Sun's Declination to be unalterable for one Day; and therefore in the *Projection of the Sphere* it is called, a *Parallel of the Sun's Declination*, and is always drawn so in the Projection: But this, strictly speaking, is not so; for they are not Parallel, but a Spiral Line, the Sun, (or rather the Earth) describes from Tropic to Tropic,

Tropic, and the Declination near the Equinoctial Points alter in an Hour considerably; but near the Tropic more slow: For they are proportional to Radius, as are the Natural Sines, to the Semidiameter of the same Circle: Therefore in any Operation where Exactness is required, you must always be careful to find the Declination of the Sun, Moon, or Star, to the precise Time of the Question, if you design to be exact in your Calculations. Special regard must be had to the Moon's true Declination (because her Motion is swift) to the time of her rising, southing, and setting, as I shall shew when I come to that Precept: Otherwise her right Ascension, her oblique Ascension and oblique Descension will not be had true.

PROB. VII.

Given, the Latitude of the Place, and the Declination of the Sun, Moon, or Star, to find their oblique Ascensions and oblique Descensions.

Example. *Anno* 1718, *July* 10, at Noon by our Tables the Sun's Place is ♋ 28 Degr. 45 Min. 5 Sec. his Declination 20 Degr. 26 Min. 52 Sec. North. I demand the oblique Ascension and oblique Descension at *London*, the time of rising and setting, *&c.* First, draw D D the parallel of Declination, and P ☉ S. That is where the Declination cuts the Horizon. Then,



In the right Angled Spheric Triangle P H ☉, are given H P the Latitude of *London*, ☉ P the Sun's distance from the North Pole, equal to the Complement of the Declination 69° 33′ 8″, to find the Angle at the Pole from Midnight.

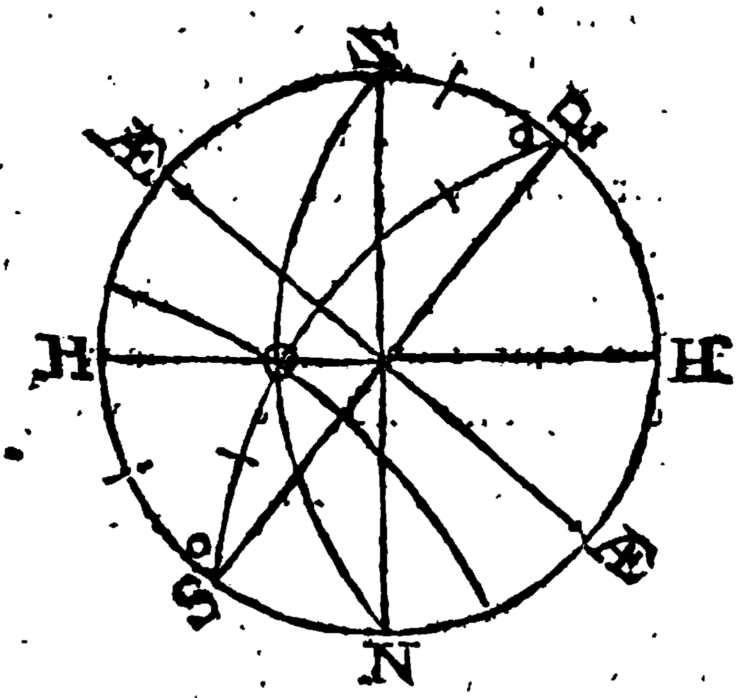
A N A-

ANALOGY.

	Deg.	Min.	Sec.	
As Radius	90	00	00—	10.
To t. of the Latitude	51	32	00—	10.099913
So t. Declination North	20	26	52—	9.571430
To Co. Sine of the Semi-nocturnal Ark	62	01	07—	9.671343

This 62 Deg. 1 Min. 7 Sec. reduced into Time is 4 H. 8 Min. 28 Sec. the Time of Sun rising. *Note*, If the Latitude of the Place, and Declination of the Sun be of different Names, that is, one North and the other South, then the Ark found by the Analogy above when reduced into Time is the Semidiurnal Ark or Time of Sun-setting.

Example. December 10, the Sun in the very beginning of ♑, I would know the true Time of his rising and setting at *London*.



In the Triangle ☉ Z P, or rather in the Triangle H ☉ S, are given the Latitude = H S, the Complement of the Sun's Declination ☉ S 66° 31′, to find the Angle H S ☉, the Semidiurnal Ark.

ANALOGY.

	Deg.	Min.	Sec.	
As Radius	90	00	00—	10.000000
To t. Latitude	51	32	00—	10.099913
So t. Declination South	23	29	00—	9.637956
To C. ſ. of the Semidiurnal Ark	56	50	57—	9.737869

These 56 Hours, 50 Min. 57 Sec. converted into Time, are 3 Hours, 47 Min. 23 Sec. 48 Thirds, the true Time of the Sun's setting; which substracted from 12 Hours, leave 8 Hours, 12 Min. 36 Sec. 12 Thirds, the true Time of the Sun's rising, on the Day and Place aforesaid; which gives the length of the Day and Night as is shewn in Prob. 5.

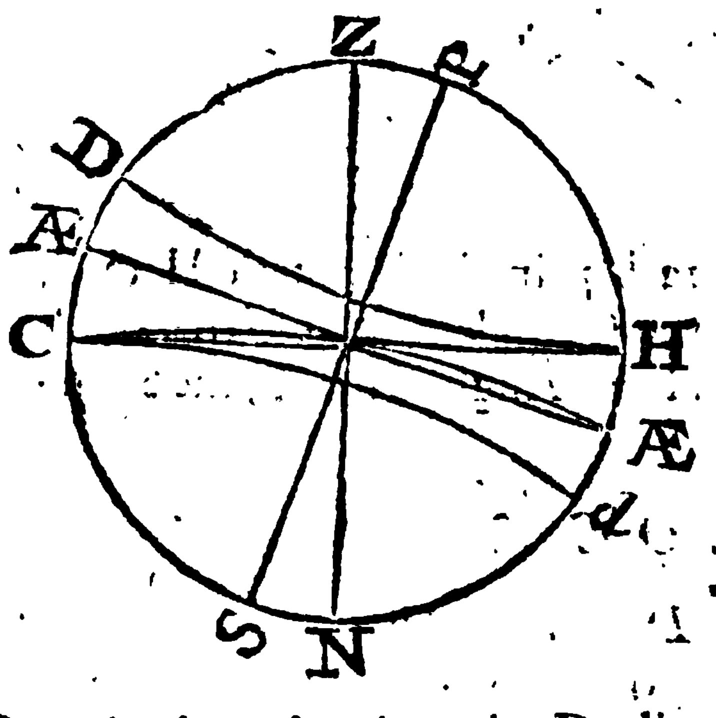
N. B. The Complement of the Arch thus found is the Ascen. Difference.

PROB. VIII.

To find the Beginning Duration and End of the longest Day, and the longest Night in any Latitude, whose Complement exceeds the Sun's Declination North and South.

When the Declination of the Sun is equal to the Complement of Latitude, and of the same Nature; that is, both North, or both South; that then the Sun never descends below the Horizon of that Place; but his Center touches in the opposite part of the Meridian. And on the contrary, when the Sun's Declination is of a different Denomination, that there the Sun never ascends above their Horizon; but its Center just touches it when upon the Meridian.

Example. Let it be required at the North Cape Latitude 71° 25′ to find that Day that the Sun begins with them, not to set for some certain Time, and also the Day when he begins to disappear, *&c.*



The Latitude being 71° 25′ North, its Complement 18° 35′ = Æ D the Sun's Declination North, where at Midnight you see it touches the Horizon at H, and continues above the Horizon all the time the Sun is going to the Tropic, and until he returns back unto the same parallel of Declination D H. So that here is no more to do than to find the Sun's Longitude answering the Declination, which in this Case is always equal to the Complement of the Latitude of the Place; as is shewed in Prob. 2.

A N A-

ANALOGY.

		Deg.	Min.	Sec.	
As Sine Sun's greateſt Declination		23	29	00	— 9.600409
To Radius		90	00	00	—10.000000
So Co. Sine Latitude of the Place		71	25	00	— 9.503360
To Sine of Sun's Long. anſwering		53	6	20	— 9.902951
one Sign ſub.		30	00	00	
Remains Sun's Place	1	23	6	20	Sub.
	6	00	0	0	From
Sun's Place	4	6	53	40	Remains.

The Day of the Month anſwering ♉ 23 Deg. 6 Min. 20 Sec. is *May* 3, and the Day anſwering the Sun's Place ♌ 6 Deg. 53 Min. 40 Sec. is *July* 19; ſo that from *May* 3, to *July* 19, the Sun never ſets at that Place; which is 77 Days.

And when the Sun's Declination 18 Deg. 35 Min. is South increaſing, its Parallel *c d* touches the Horizon when the Sun comes to ♏ 23 Deg. 6 Min. 20 Sec. which happens on *November* 4, and when the Sun has returned back again from the Tropic of ♑, and has 18° 35′ of South Declination, the Parallel C *d* now touches the Horizon, and the Meridian at C, and he begins then to riſe, his Longitude is ♒ 6° 53′ 40″, which happens upon the 15th of *January*; ſo that from *Nov.* 4, to *Jan.* 15, is 72 Days; all which time the Sun never riſes to them in the Latitude of 71° 25′ North: And this Night of 72 Natural Days is ſhorter than their longeſt Day by 5 Natural Days. But in the ſouthern Parts of the World theſe Appearances are juſt contrary, *viz.* when 'tis Day in the North 'tis Night in the South, and when 'tis Night in the North 'tis Day in the ſouthern Hemiſphere. What has been ſaid here for the Latitude of the North Cape, the ſame is to be obſerved of all other Parallels of Latitude within the Polar Circles.

But herein is to be conſidered, that the Calculation above is performed, ſuppoſing the Sun to be free from Refraction; (See the Word *Refraction*) ~~but ſince~~ it is not ſo, but that he is Refracted in the Horizon more than half a Degree in our Latitude, therefore it follows that the Inhabitants will ſee the Sun ſooner than *May* the 3d, which is the Day truly when they might expect him; and he will continue above their Horizon longer than *July* the 19th, which is the Day that truly he will begin to diſappear to them at Midnight; ſo that if the true quantity of

Refractions were know in all Latitudes, then by the above Investigation may the apparent Days of the Sun's first appearing, and the Day of his disappearing be found, otherwise not.

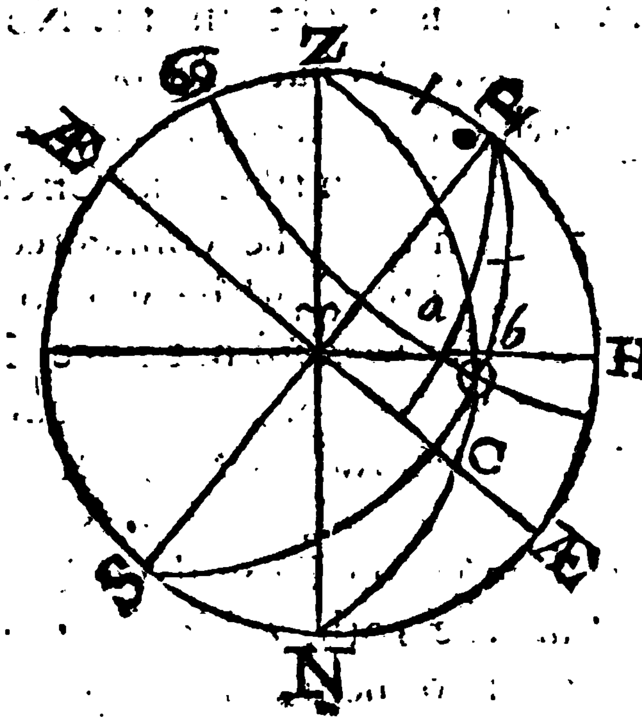
PROB. IX.

Given, the Latitude of the Place, the Sun's Declination, and Horizontal Refraction; to find the Apparent Time of the Sun's rising and setting.

The apparent Time of the rising and setting of the Heavenly Bodies always differs from the true Time; and this is by the Rays of Light passing through different Mediums, which causes them to be turned or bent out of that straight Line in which they should directly pass. This visible Time is of very great Moment in the Eclipses of the Luminaries, when the Sun or Moon rises or sets eclipsed, to find how much of their Diameters are then obscured, at the visible Time of their rising or setting.

Example. Let it be required to find the apparent or visible Time of the Sun's rising and setting the 10th Day of *June*, when he is in the Tropic of *Cancer*?

In the adjacent Diagram, let ♈ H represent part of the Horizon, Æ Æ the Equinoctial, P S the Earth's Axis, ♋ *a* the Tropic; the Sun truly rises at *a*, but is seen to rise at *b*, when he is 33′ = *b* ☉ below the Horizon. In the oblique Angled Spheric Triangle Z P ☉ are given Z P, the Complement of the Latitude 38 Degr. 28 Min. Z ☉, the Distance of the Sun from the Vertex 90 Degr. 33 Min. and P ☉, the distance of the Sun from the north Pole, equal to the Complement of the Declination 66 Degrees 31 Min. to find the Angle Z P ☉, the visible Semidiurnal Ark, or apparent time of Sun setting. Then by the 11th Case of oblique Angled Spheric Triangles, in page 258, of my *Young Mathematician's Companion*, I perform the Work thus:



To

	°	′		°	′
To Z *h*	90	00	Z P	38	28
add *h* Refraction		33	P ☉	66	31
Sum is Z ☉ =	90	33	X	28	3
Half	45	16½	half	14	1½

Or thus :

	°	′	°	′
Z P =	38	28		
Z ☉ =	90	33		
P ☉ =	66	31		
Sum	195	32		
½ =	97	46	97	46
—	38	28	66	31
X =	59	18	X = 31	15

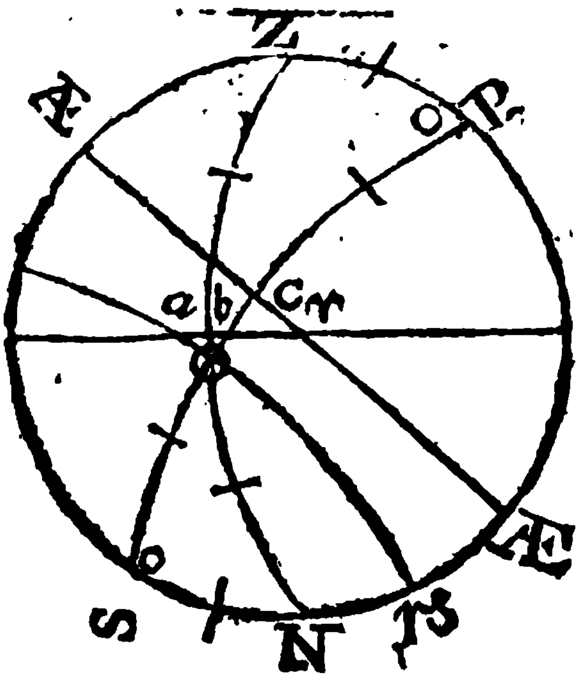
	°	′
	45	16½
Add, and Subtract	14	1½
	Z—59	18
	X—31	15

	°	′		
Z P, S.	38	28	Co. Ar.	0.206168
P ☉, S.	66	31	Co. Ar.	0.037547
Z, S.	59	18	——	9.934424
X, S.	31	15	——	9.714977
Z, Logarithms			——	19.893116
Sine of 62	9	19″	½	9.946558

Doubled, = 124 Degr. 18 Min. 38 Sec. reduced into Time is 8 H. 17 Min. 14 Sec. 32 Thirds, the apparent Time of the Sun's ſetting, equal to the Semidiurnal Ark, whoſe Complement to 12 Hours is 3 H. 42 Min. 45 Sec. 28 Thirds, the apparent Time of his riſing on the given Day at *London*. But the true Time of the Sun's riſing and ſetting is 3 H. 47 Min. 23 Sec. 44 Thirds, and 8 H. 12 Min. 36 Sec. 12 Thirds, by which the Sun is ſeen to riſe ſooner and ſet later by 4 Min. 38 Sec. 16 Thirds, which makes the length of the apparent Day longer than the Aſtronomical Day by 9 Min. 16 Sec. 32 Thirds.

Example.

Example 2. Let it be required to find the apparent Time of the rising and setting of the Sun *December* 10, when he is in the Tropic of ♑.



——In the oblique Angled Spheric Triangle ☉ Z P, are given Z P the Complement of the Latitude 38 Degr. 28 Min. ☉ P, the Sun's distance from the North Pole, 113 Degr. 29 Min. and Z ☉, the Sun's distance from the Vertex 90 Degr. 33 Min. to find the Angle at the Pole ☉ P Z?

OPERATION.

	°	'
Z *b*	90	0
b Refraction	0	33
Sum is Z ☉	90	33
Half	45	16½
Add and Sub.	37	30½
Z	82	47
X	7	46

	°	'
C P 90 + C ☉ 23	29 = P ☉ 113	29
Z P =	38	28
X	75	1
½	37	30½

Or thus:

	°	'		°	'
Z P =	38	28			
☉ P =	113	29			
☉ Z =	90	33			
Z =	242	30			
½ =	121	15		121	15
Z P =	38	28	☉ P	113	29
X =	82	47	X =	7	46

	° ′		° ′		
☉ P	113 29	Complement	S. 66 31	Co. Ar.	0.037547
Z P			S. 38 28	Co. Ar.	0.206168
Z			S. 82 47		9.996546
X			S. 7 46		9.130781
Z Logarithms			° ′ ″		19.371042
Half is Sine of			28 59 47		9.685521
Doubled is			57 59 34		

Reduced into Time is 3 Hours 51 Min. 58 Sec. 16 Thirds, the Semidiurnal Ark, or apparent Time of the Sun's setting; whose Complement to 12 Hours is 8 Hours 8 Min. 1 Sec. 44 Thirds, the apparent Time of the Sun's rising: But the true Time of the Sun's rising and setting at *London* on the same Day, is 8 Hours 12 Min. 36 Sec. 12 Thirds, and 3 Hours 47 Min. 23 Sec. 48 Thirds, by which you see the Sun rise sooner and set later by 4 Min. 34 Sec. 28 Thirds; which makes the length of the Apparent Day longer than the Astronomical, by 8 Min. 8 Sec. 56 Thirds. And thus, by these Examples may you find the apparent Time of the Moon's rising and setting.

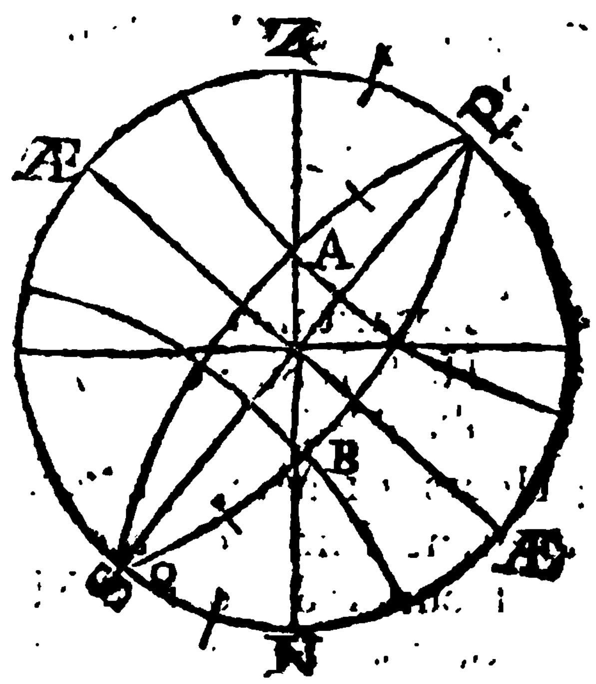
And as this Refraction occasions an Error in the Time of the Sun's rising and setting; so it likewise doth in the Amplitude: For the true Amplitude is ♈ *a*; but the Visible, ♈ *b*, which you see in the little Right-Angled Spheric Triangle ♈ *c b* in these Schemes; and as in the first the Declination is increased by the Refraction 33 Minutes; so the Visible Amplitude will be 4° 51′ N. but in the last Scheme it is diminished 33′. So the visible Amplitude 38° 47′ South less than the true. And this ought to be carefully minded by the Mariner; otherwise he will never attain the true Variation of the Compass, if he does not mind to take the Visible Amplitude instead of the True.

PROB. X.

Given, the Latitude of the Place, and the Sun's Declination, to find the Time when he will be due East and West,

Example. Let the Sun be in the beginning of ♋ and ♑, and let it be required to find the Time he is due East and West in the Latitude of *London.*

Where



Where the Tropics cut the East and West Azimuth, *viz.* at A and B, there draw two great Circles, as P A S and P B S, by which are formed two Rect-angled spheric Triangles AZP, and BNS Rect-angled at Z and N; in which are given A P = B S, the Complement of the Sun's Declination 66 Degrees 31 Minutes, and Z P = S N, the Complement of the Latitude 38 Degrees 28 Minutes, to find the Angles A P Z, and B S N, the Times from Noon and Midnight.

ANALOGY.

	Deg.	*Min.*	
As Radius	90	00--	10.000000
To T. S N = Z P	38	28--	9.900086
So C. t. S B = A P	66	31--	9.637256
To C. f. B S N = A P Z	69	41--	9.538042

Or by Transposition.

As Radius	90	00--	10.000000
To C t. Latitude	51	32--	9.900086
So T. Declination	23	29--	9.637956
To S. Sun's distance from 6 o'Clock	20	12--	9.538042

This 69 48 reduced into Time, is 4 H. 39 Min. 12 Sec. the Time in the Afternoon when the Sun is over the west Point of the Compass in Summer, or under it in Winter, which taken from 12, leaves 7 Hours 20 Min. 48 Sec. in the Morning: Or its Complement 20, 12, converted into Time, makes 1 H. 20 Min. 48 Seconds; and sub. from 6, leaves 4 H. 39 Min. 12 Seconds, the Time as before, when the Sun is due East and West, when in the Tropic ♋.

N. B. The Sun is never upon the prime Vertical at 6 o'Clock, but when he is in the Equinoctial; and consequently can never stay 12 Hours upon a south erect direct Plane but when in the Equinoctial. For when the Sun is in the Tropic of Cancer, his stay upon an erect direct south Plane is only 9° 18' 24'' as appears by the Work above.

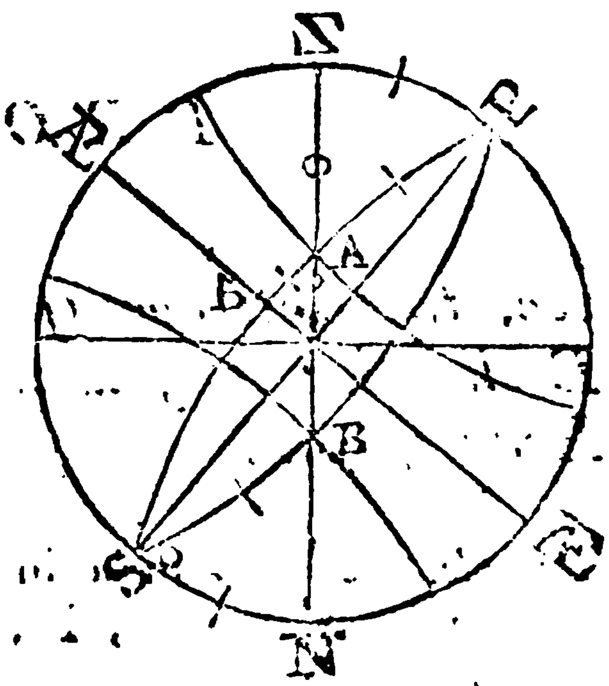
PROB.

PROB. XI.

Given, the Latitude of the Place, and the Sun's Declination, to find the Sun's Altitude when he is due East and West.

Example. Let the Sun be in the Tropic of ♋ and ♑; and let it be required to find his Altitude at *London* when he is upon the Prime Vertical Circle?

Draw two great Circles as PAS and PBS, to cut the Prime Vertical in the Tropics at A and B, and then there is formed the Rectangled Spheric Triangles AZP and B N S Right-angled at Z and N, in which are given A P, the Sun's Distance from the Pole = B S, and Z P = S N the Complement of the Latitude 38° 28′, to find Z A = B N the Complement of the Sun's Altitude, when he is upon the Prime Vertical Circle.



ANALOGY.

	Deg.	Min.	
As C. S. of Z P	38	28--	9.893745
To Radius	90	00--	00.000000
So C. S. A P	66	31--	9.600409
To C. S. Z A	59	24--	9.706664

Whose Complement 30° 36′ is the Sun's Altitude sought.

Or, by Transposition in the Triangle ♈ b A.

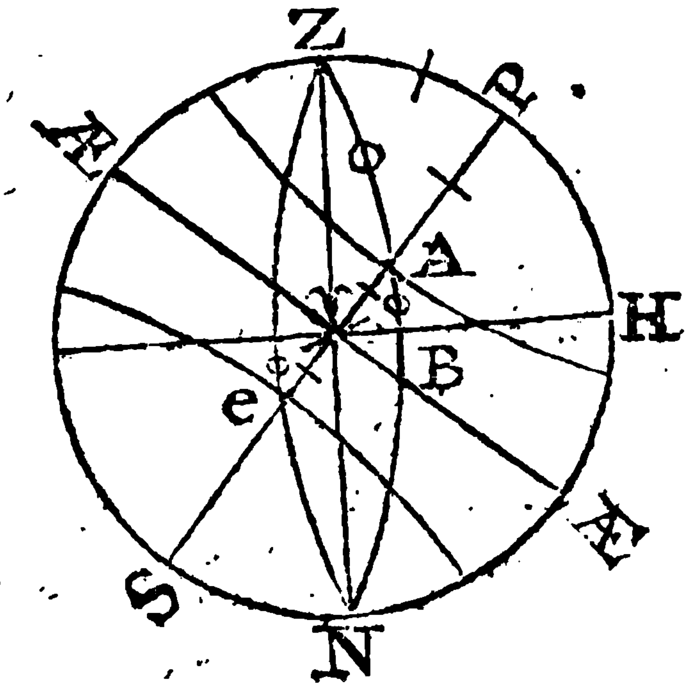
		Deg.	Min.	
As the S. of the Latitude Angle	B ♈ A	51	32--	9.893745
To Radius		90	00--	10.000000
So S. Declination	*b* A	23	29--	9.600409
To S. of the Altitude	♈ A	30	36--	9.706664

The Sun's Altitude when in northern Signs, as before; and when in southern Signs, it is his Depression below the Horizon.

PROB. XII.

Given, the Latitude of the Place, and the Sun's Declination, to find the Sun's Azimuth at the Hour of Six.

Example. Let the Sun be in the beginning of ♋ or ♑ in the Latitude of *London*; I would know the Sun's Azimuth at the Hour of Six?



Draw Z A N, and Z *d* N to intersect the Earth's Axis in the Tropics.

In the Rect-angled Spheric Triangle A P Z are given A P, the Complement of the Sun's Declination, Z P, the Complement of the Latitude of *London*, to find the Angle A Z P the Sun's Azimuth from the North = B H.

ANALOGY.

	Deg.	Min.	
As t. A P	66	31--	10.362044
To Radius	90	00--	10.000000
So S. Z P	38	28--	9.793832
To C. t. *Angle* A Z P	74	53--	9.431788

Which is the Sun's Azimuth from the North, in ♒ and from the South in ♑

By Transposition in the Angle ♈ A B.

	Deg.	Min.	
As Radius	90	00--	10.000000
To t. ♈ A, the Sun's Declination	23	29--	9.637956
So C. S. *Angle* A ♈ B, the Lat.	51	32--	9.793832
To t. ♈ B, Azimuth from the East and West.	15	07--	9.431788

Note, When the Sun is in the northern Signs, the first Analogy is the Azimuth from the North; but when in southern Signs, from the South; whose Complement to a Quadrant is the Azimuth from the East or West.

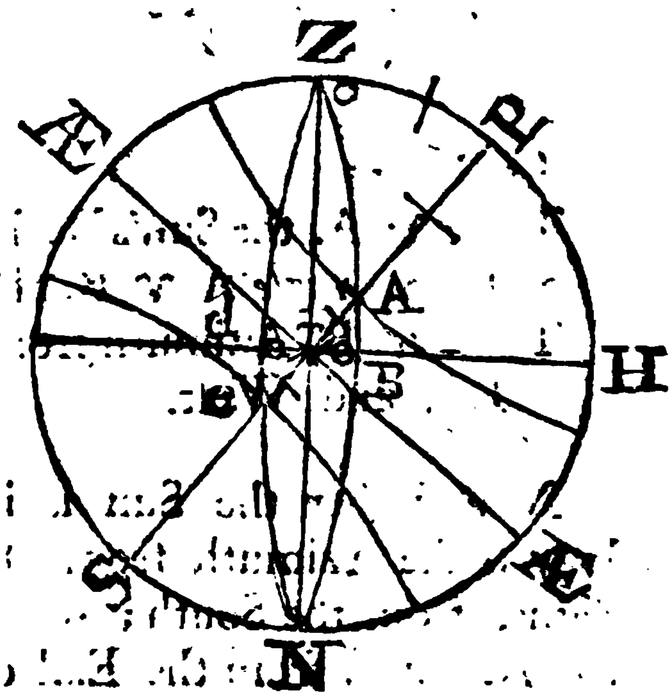
Or, to find it from the North, or South, you may say,

	Deg.	Min.	
As Radius	90	00--	10.000000
To t. Sun's Declination	23	29--	9.637956
So C. ſ. of the Latitude	51	32--	9.793832
To C t. of Azimuth	74	53--	9.431788

PROB. XIII.

Given, the Latitude of the Place, and the Sun's Declination, to find the Sun's Altitude at the Hour of Six.

Example. Let the Sun be in the beginning of ♋ or ♑, and the Latitude of *London* I demand the Sun's Altitude at Six in the Morning, or Depression under the Horizon at Six at Night.



Draw the two great Circles Z A N, and Z ♈ N, to cut the Tropic and Axis in D and *e*; Then in the Triangle A P Z = *e* S N, are given Z P 38° 28', the Complement of the Latitude; and A P the Complement of the ☉ Declination 66° 31', to find A Z the Complement of the Altitude: Or in the Triangle A B ♈ = △ *e d* ♈ are given ♈ A 23° 29', the Sun's Declination, and *Angle*, B ♈ A = 51, 32, the Latitude of the Place, to find B A the Altitude, or *d e* the Depression at 6 o'Clock.

ANALOGY.

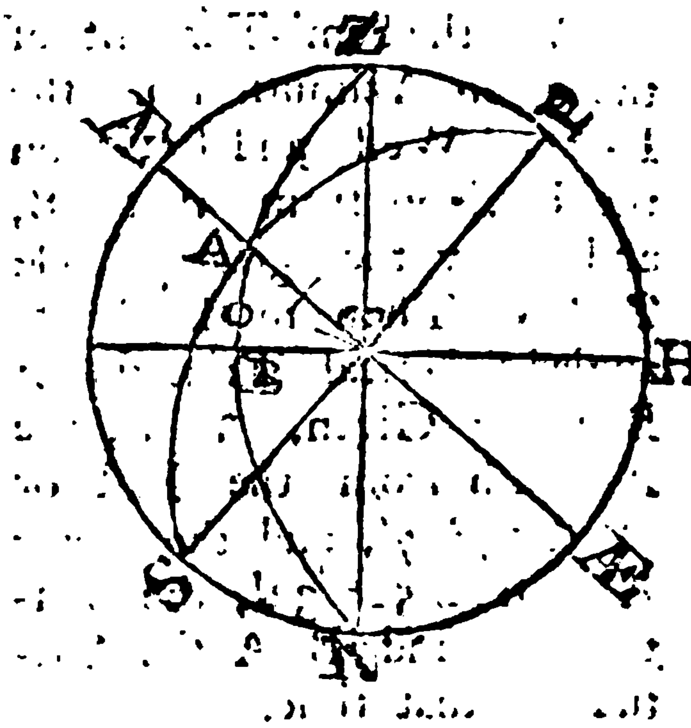
	Deg.	Min.	
As Radius	90	00	10.000000
To S. Sun's Declination	23	29	9.600409
So ſ. Latitude	51	32	9.893745
To ſ. Altitude	18	11	9.494154

PROB.

PROB. XIV.

Given, the Latitude of the Place, and the Hour of the Day, to find the Sun's Altitude when he is in the Equinoctial.

Example. Let the Latitude be *London*, and the Sun in the Equinoctial at 10 in the Morning, or at 2 in the Afternoon; what is then his Altitude?



Take the Semi-tangent of four Hours, which is the Time from 6, and set it on the Equinoctial from ♈ to A; and with the Secant of 30 Deg. draw P A S, and also draw Z A N: Then in the Right-angled Spherical Triangle ♈ B A, are given, ♈ A, the Time from 6 = 60°, and the Angle A ♈ B = 38° 28′ the Complement of the Latitude, to find B A the Altitude at that Time.

ANALOGY.

	Deg.	Min.	
As Radius	90	00	10.000000
To S. of Time from 6	60	00	9.937531
So C. S. of the Latitude	51	32	9.793832
To S. A B the Altitude	32	35	9.731363

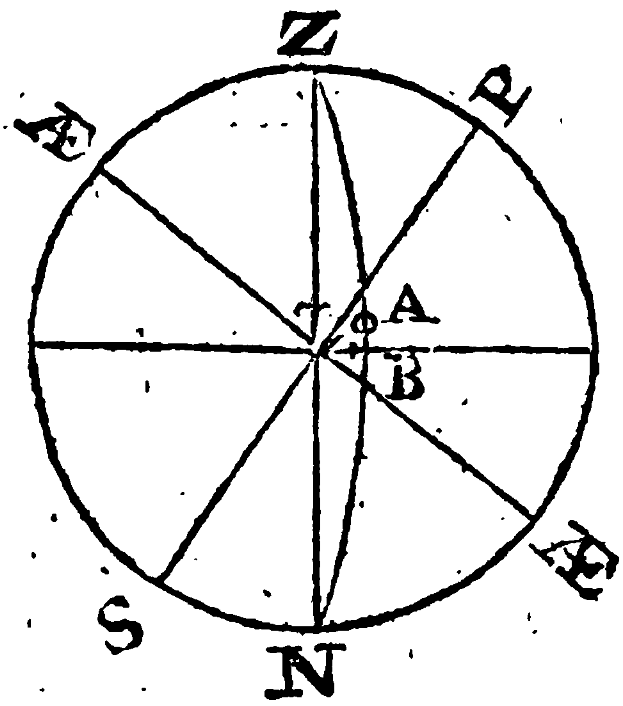
PROB.

PROB XV.

Given, the Latitude of the Place, and the Sun's Azimuth, to find the Altitude.

Example. Let the Latitude of the Place be *London*, and the Sun's Azimuth from the East or West 15° 7′ northward; what is then the Sun's Altitude? ☉ in 0° ♋.

Take the Semi-Tangent of the given Azimuth from the East and West, and set it on the Horizon from ♈ to B, and draw the great Circle Z B N: Then in the Rectangled Spherical Triangle ♈ B A are Given, ♈ B, the Azimuth from the East or West 15° 7′, and the Angle A ♈ B = 51° 32′, the Latitude, to find B A the Altitude at that time.



ANALOGY.

	Deg.	Min.	
As C. t. Latitude	51	32--	9.900086
To Radius	90	00--	10.000000
So Sine Azimuth	15	07--	9.416283
To t. Altitude	18	10--	9.516197

By Transposition.

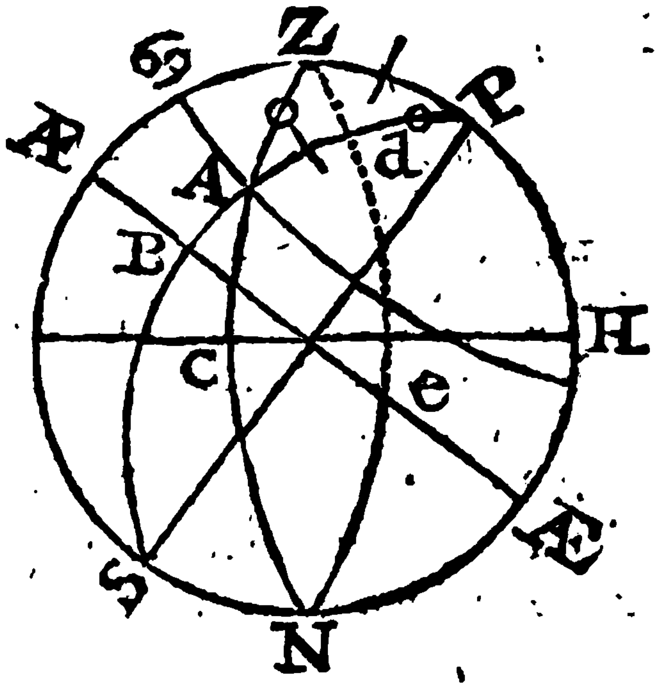
	Deg.	Min.	
As Radius	90	30--	10.000000
To t. Latitude	51	32--	10.099913
So S. Azimuth from East	15	07--	9.416283
To t. Altitude	18	10--	9.516196

PROB.

PROB. XVI.

Given, the Latitude of the Place, the Sun's Declination, and Hour of the Day, to find the Sun's Altitude.

Example. Admit the Latitude of the Place be 51° 32′ N. the Sun's Declination 23° 29′ N. at 10 in the Morning, or 2 in the Afternoon (for here the Declination alters but little in that Time) that is, 2 Hours diſtance from the Meridian; I would know the Sun's Altitude?



From the Center of the Primitive Circle ſet off four Hours or 60 Deg. by help of the Semi-Tangents on the Sector, upon the Equinoctial to B, and with the Secant of 30 Deg. draw the great Circle P B S, and alſo draw Z A N to interſect each other in the Tropic, the place of the Sun at 10 or 2 o'Clock; by which there is formed the Oblique-Angled Spheric Triangle A Z P, in which are given Z P Complement of Latitude 38° 28′, A P the Complement of the Sun's Declination 66° 31′, and the Angle Z P B 30, to find A Z the Complement of the Altitude or Zenith-diſtance, which by the ſixth Caſe of Obliques is anſwered thus; by letting fall the Perpendicular Z *d*.

Firſt, For the Segment *d* P, I ſay,

	Deg.	*Min.*
As C. t. of Z P	38	28--10.099913
To Radius	90	00--10.000000
So C. ſ. *Angle* Z P A	30	00-- 9.937531
To t. *d* P ſub.	34	32-- 9.837618
From A P	66	31
Remains A *d*	31	59

Or

Or, by Transposition, say,

	Deg.	Min.	
As Radius	90	00 --	10.000000
To C. t. of the Latitude	51	32 --	9.000086
So S. Sun's distance from 6,	60	00 --	9.937531
To t. of the fourth Ark	34	32 --	9.837617

A general RULE.

If the Time given be between 6 in the Morning, and 6 at Night, this fourth Ark must be substracted from the Sun's Distance from the North Pole: But if the Time given be before 6 in the Morning, or after 6 at Night, then add this fourth Ark to the Sun's Distance from the North Pole; the Sum or Difference is the fifth Ark.

OPERATION.

From a Quadrant	90	00
Take the Sun's Declination North	23	29
Rest Sun's distance from the north Pole	66	31
Fourth Ark sub.	34	32
Remains the fifth Ark	31	59

But if the Sun have south Declination, then it must be added to 90, which gives his distance from the north Pole.

Now say,

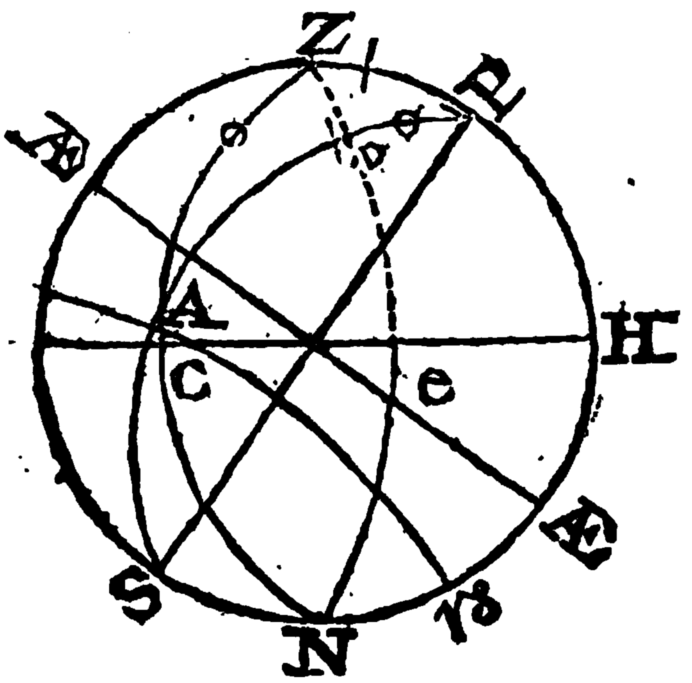
	°	'	"	
As C. s. of the fourth Ark Co. Ar.	34	32	00 --	0.084179
To C. s. of the fifth	31	59	00 --	9.928499
So S. Latitude	51	32	00 --	9.893745
To S. Altitude C A	53	44	38 --	9.906423

Example 2. Let the Sun be in the Tropic of *Capricorn*, Latitude and Time of the Day as in the last Example: What's the Altitude?

OPE

OPERATION.

As Radius	90	00--10.000000	
To C. t. Latitude	51	32-- 9.900086	
So S. Sun's Distance from 6	60	00-- 9.937531	
To t. of the fourth Ark	34	32-- 9.837617	
Sun's Distance from N. Pole	113	29	
Remains 5*th*. Ark	78	57	



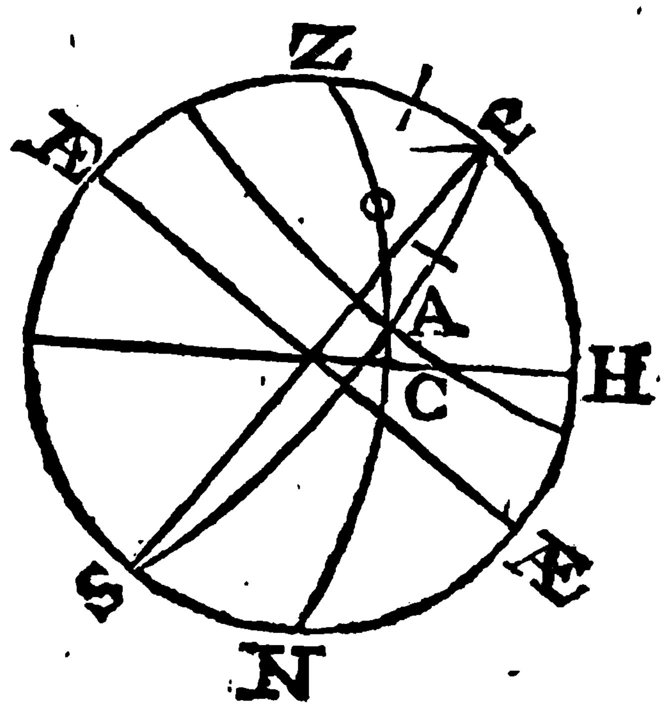
Now say,

	Deg.	Min.
As C ſ. of 4 ArkCo. Ar	34	32--0.084179
To C. 5 Ark	78	57--9.282544
So ſ. Latitude	51	32--9.893745
To S. Altitude = C A	10	30--9.260468

Example. 3. *July* 13, Let the Sun's Declination be 20 Deg. north, and the Time 10 Minutes before 5 in the Morning, or 10 Minutes past 7 at Night, and Latitude 51 Deg. 32 Min. north; I demand the Sun's Altitude? The Time from 6 is 1 Hour 10 Minutes; which converted into Degrees, is 17 Degrees 30 Minutes.

Now ſay,

	Deg.	Min.
As Radius	90	00--10.000000
To C. t. Latitude	51	32-- 9.900086
So S. Sun from 6	17	30-- 9.478142
To t. of 4 Ark	13	26-- 9.378228
Sun from north Pole add	70	00
Sum is the 5*th* Ark	83	26

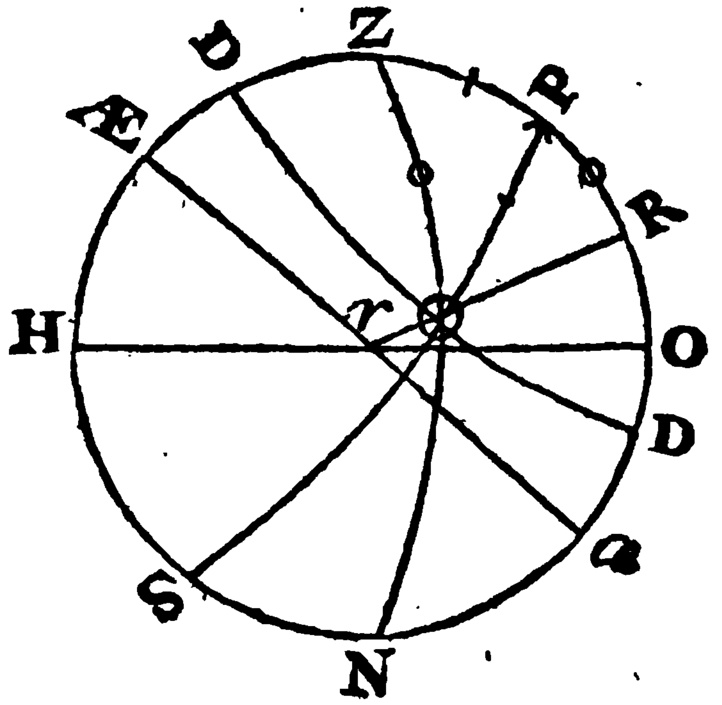


	Deg.	Min.
As C. ſ. of 4*th* Ark Co. Ar.	13	26--0.012047
To C. ſ. of 5*th*	83	26--9.058271
So ſ. Latitude	51	32--9.893745
To ſ. Altitude C A	5	17--8.964063

Or if the time before 6 = 17° 30′, be ſubtracted from Midnight, or 90, there remains the Angle ☉ P O = 72 30 in the following Scheme, then let fall the Perpendicular ♈ ☉ R, and ſay,

As

	Deg.	Min.	
As C. t. ⊙ P	70	0	9.561066
To Radius	90	0	10.000000
So C S P	72	30	9.478142
To t. P R	39	34	9.917076
Add z P	38	28	
Sum = z R =	78	2	



Now say,

	Deg.	Min.		
As C S. P R	39	34	Co. Ar.	0.113011
To C S. z R.	78	2		9.316689
So C S. ⊙ P	70	0		9.534052
To C S. ⊙ z	84	43		8.963752

Whose Complement to 90° is 5° 17′ the Sun's Altitude as before.

And after the same manner may the Altitude of the Sun, Moon or Star be found: But in things that require Exactness, you must be sure to find the Declination to the Time proposed, as I shall shew in its proper Place; but in the Example above, I supposed the Declination unalterable for that Day, which is not so itself, but will serve the present Purpose well enough. See *Prob.* 6. By the same Investigation I have found at *London* the Sun's Altitude as is here set down. Declination 19° N. 1725 *July* 17.

			°	′
at	2	Hours Altitude, is	49	51
	3		45	08
	3		37	49
	4		33	18

 And

And 1725, *Aug.* 6, at 8 Morning, Declination 13 Degrees 27 Minutes N. Sun's Altitude is 29 Degrees *ferè* *Aug.* 19, Declination 8 Degr. 59 Minutes N. Altitude 45 Degr. 42 Min. at 1 o'Clock. *Aug.* 21, at 10 ½ Hours, Altitude 41° 38'. *Aug.* 26, at 11 Hours 27 Min. 28 Sec. Altitude 44 Deg. 22 Minutes. *Anno* 1726, *Jan.* 4, at one o'Clock, Sun's Altitude is 16 Degrees 8 Minutes. *April* 1, at 9 Morn. Altitude 33 Degr. 33 Minutes. *Aug.* 2*d*, 20 H. Altitude, 29 Degr. 48 Minutes at 8 H. 30 Minutes Morning, Altitude, 34 Degr. 14 Minutes. *Aug.* 16 at 2 o'Clock, Altitude 41 Degr. 54 Minutes; but half an Hour sooner it is 44 Degr. 42 Minutes. *Anno* 1727, *May* 27, at 10 Morning, Sun's Altitude was 53 Degr. 6 Minutes *July* 6, at 10, Altitude 51 Degr. 54 Min. and at 6 it was 16 Deg. 34 Minutes: These Altitudes I observed at *London* with my Astronomical Quadrant; and correcting them by Refractions and Parallax, I found them all to agree exactly; by which I pronounce the Elevation of the Pole to be truly asserted.

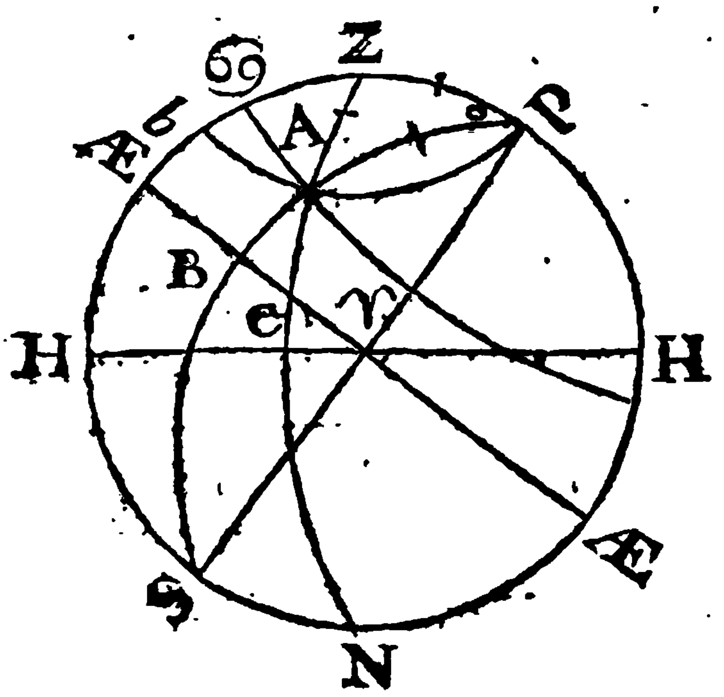
PROB. XVII.

Given, the Latitude of the Place, the Sun's Declination and Altitude, to find the Hour of the Day?

Example. Let the Latitude of the Place be 51 Degr. 32 Minutes North; Sun's Declination 23 Deg. 29 Min. North, and Altitude 53 Degr. 44 Min. 38 Seconds: What's the Hour of the Day?

With the Chord of 60 from the Sector, opened to the Radius ♈ Æ, sweep the Primitive Circle; draw P S the Earth's Axis, to the Latitude of *London*, and Æ Æ at right Angles for the Equinoctial, and H H the Horizon.

Take



Take the given Altitude 53 Degr. 44 Min. 38 Sec. from the Line of Chords, and set it upon the Meridian from H to *b* and *o*, and with its Co. Tangent draw *b* A *o* which is a Parallel of Altitude; and where it cuts the Tropic or Parallel of Declination, which is at A, draw P A S and Z A N; so is there truly projected the oblique angled spheric Triangle A Z, P in which are given Z P, the Complement of the Latitude 38 Degrees 28 Minutes, A P the Complement of the Declination 66 Degrees 31 Minutes, and A Z the Complement of the Altitude 36 Degrees 15 Min, 22 Seconds, to find the Angle Z P A, the Hour from Noon? Which by the 11th Case of oblique angled spherical Triangles I perform thus:

OPERATION.

Z P Complement Latitude ———	38	28	00
A P Complement Declination ———	66	31	00
A Z Complement Altitude ——— ———	36	15	22
Sum of all three ——— ———	141	14	22
Half Sum ——— ——— ———	70	37	11
Complement Latitude sub. ——— ———	38	28	00
Difference ——— ———	32	9	11
Half Sum ——— ———	70	37	11
Complement Declination sub. ———	66	31	00
Difference ——— ———	04	06	11

Having

Having prepared the Work above, then proceed thus:

		Deg.	Min.		
Sides	Z P Compl. Latit. Sine Co. Ar.	38	28	00	0.206168
	A P Compl. Decl. Sine Co. Ar.	66	31	00	0.037574
Difference of	Co. Latit. and ½ Z Sine	32	09	11	9.726062
	Co. Decl. and ½ Z Sine	04	06	11	8.854613

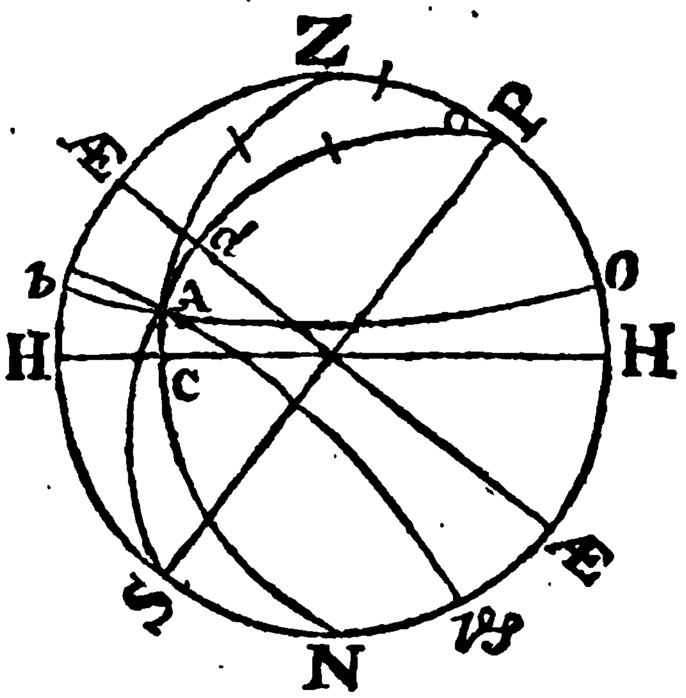
Sum of the Logarithms 18.824390
Half, is the Sine of 14 58 18—9.412195
Doubled, is 29 56 36 converted into Time, is 1 H. 59 Min. 46 Sec. 24 Thirds from Noon; that is, 10 H. 0 Min. 13 Sec. 36 Thirds in the Morning. And such was the Hour of the Day at the time of this Observation.

Or the Angle at the Pole may be found as in *Problem* 9.

Example 2. Admit the

		°	′	
	Latitude	51	32 N.	What's the Hour of Day.
Sun's	Declination	23	29 S.	
	Altitude	10	30	

Draw the Parallel of Altitude *b* O, by help of the Line of Chords on the Sector, and it will intersect the Tropic of ♑ (which is here the Parallel of the Sun's Declination) in the Point where the two oblique Circles P *d* S and Z A N must pass. Therefore, in the oblique angled spherical Triangle A Z P, all the sides are given to find the Angle at the Pole.



OPERA-

OPERATION.

	°	'
To P *d*	90	00
Add A *d* Declination South	23	29
Z is A P Sun from N. Pole	113	29
Z P Complement Latitude	38	28
A Z Complement Altitude	79	30
Sum	231	27
Half	115	43½
Complement Latitude sub.	38	28
Difference	77	15½
Half Sum	115	43½
Sun from N. Pole sub.	113	29
Difference	2	14½

		°	'	"	
Sides	Z P Comp. Latitude S. Co. Ar.	38	28	00	0.206168
	A P Sun from N. Pole 113° 29' Complement	66	31	00	0.037547
Difference	Co. Latit. ½ Z. Sine	77	15	30	9.989171
	Co. Decl. ½ Z. Sine	2	14	30	8.592335

Sum of the Logarithms 18.825221
Half is the Sine of 14 59 11—9.4126105
Doubled is 29 58 22. Converted into Time, is 1 H. 59 Min. 53 Sec. 28 Thirds from Noon: Consequently the Time of the Day is 10 H. 0 Min. 6 Sec. 32 Thirds in the Morning.

Or, if it be wrought as I have shewed in *Prob.* 9. the Time will be the same as is found above.

EXAM-

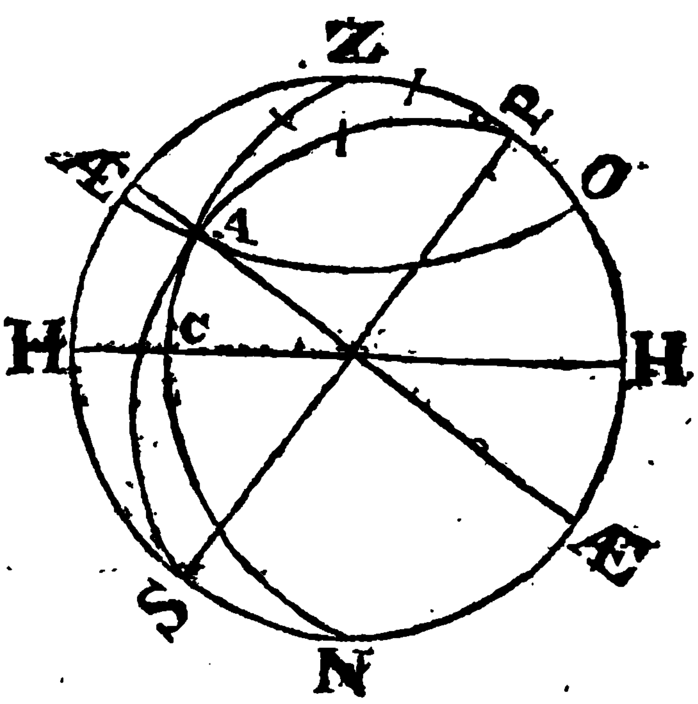
EXAMPLE.

	°	′			°	′
Side oppos. to the required Angle	79	30	Sides	Z P	38	28
Half	39	45		A P	113	29
Half Z. 2 Sides including required *Angle*	37	30 ½		X	75	1
Z	77	15 ½		½	37	30 ½
X	2	14 ½				

Thus you see the first part of the Work is the same; therefore the Angle at the Pole will be the same as is found in the last Work; for 'tis needless to work one thing over twice.

Example 3. Admit at *London* I observe the Sun in the Equinoctial, and his Altitude to be 32 Degr. 35 Minutes? I demand then the Hour of the Day?

Take the Chord of 32 Degr. 35 Min. and set it from H to Æ and O; with the Tangent of its Complement draw the Parallel of Altitude Æ A O, and it will cut the Equinoctial in A, through A (by the Doctrine of *Spheric Geometry.*) Draw P A S and Z A N, by which you have the oblique spheric Triangle A Z P, in which are all the Sides given, to find the Angle at the Pole, or Time from Noon when the Observation was made.



The Operation stands thus, as in *Prob.* 9.

	Deg.	Min.		Deg.	Min.
A Z Compl. Altit.	57	25	A P Sun from N. Pole	90	00
Half	28	42	Z P Compl. Latit.	38	28
Half Difference	25	46	Difference	51	32
Z	54	28 ½	Half	25	46
X	02	56 ½			

Now

Now proceed thus:

		° ′		
Compl. Latit.	Sine	38 28	Co. Ar.	00.206168
Sun from N. Pole	Sine	90 00		10.000000
Sum,	Sine	54 28 ½		9.910546
Difference	Sine	02 56 ½		8.710278

Sum of the Logarithms		18.826992
Half is the Sine of	15 1 3″	9.413496
Doubled is	30 2 6.	Converted into Time

is 2 Hours, 8 Seconds, 24 Thirds from Noon, that is, 59 Min. 51 Sec. 36 Thirds past 9 in the Morning. *Note*, When any of the Sides of the Triangle are a Quadrant, as here A P is so; then the Logarithm or Sine of 90 egrees must be omitted in the Work, as you see above I have taken no Notice of it. And thus 'tis Evident how the true Hour of the Day may be gained on any part of the Globe, if you have but a good Quadrant to take the Altitude to Minutes of a Degree; which is of excellent use in the Observation of Solar Eclipses, regard being had to the Parallaxes and Refraction; and also in finding the true Hour of the Night by the Moon and Stars, as I shall demonstrate in the next Section.

Secondly, I shall subjoin another Method to find the true Hour of the Day, by having the Latitude of the Place, Sun's Declination and Altitude; which is that published by *John Collins*. But because he delivered it very abstrusely, I shall here explain it by way of Example. At *London*, on *February* 25, I observed the Sun to have 25 Degrees Altitude, and 4 Degrees, 47 Min. Declination South; What's the Hour?

First, by *Prob.* 13. I find the Sun's Depression at the Hour of 6 to be 3° 44′: This remaining fixed for all that Day, the Sun's Declination being supposed not to vary.

Now say, As Co. Sine of the Sun's Declination,

To the Secant of the Latitude;

So in Summer is the Difference, in Winter the Sum of the Sines of the Sun's Altitude, observed, and of his Altitude or Depression at the Hour of Six,

To the Sine of the Hour from 6, towards Noon in Winter, and in Summer also, when the given Altitude is greater than the Altitude at 6; but when it is less, than towards Midnight.

OPERATION.

	Deg.	Min.		
C. ſ. of { Latitude	51	32	Co. Ar.	0.206168
C. ſ. of { Declination	4	47	Co. Ar.	0.001515
Sum, is the fixed Logarithm				0.207683
Given Altitude Natural Sine	25	0		4.226183
Sun's Depreſſ. at 6. Nat. Sine add	4	47		.651129
Sum, is Nat. Sine of	29	11		4.877312
Logarithm Sine	29	11		9.688069
Fixed Logarithm add				0.207683
Z is the Logar. Sine of	51	52		9.895752

which Converted into Time, is 3 h. 27ʹ 28ʹʹ + 6 = 9 h. 27ʹ 28ʹʹ the Time in the Forenoon when the Obſervation was made.

Example 2. Latitude of the Place 51° 32ʹ North, Sun's Declination 23° 29ʹ N. and Altitude 53° 44ʹ 38ʹʹ. What's the Hour?

Firſt by *Prob.* 13. the Sun's Altitude at 6 is 18° 11ʹ.

Now the Work ſtands thus:

	Deg.	Min.		
C. ſ. of { Latitude	51	32	Co. Ar.	0.206168
C. ſ. of { Declination	23	29	Co. Ar.	0.037547
Sum, is the fixed Logarithm				0.243715
Given Altitude, N. Sine	53	45		8.064446
Sun's Altitude at 6 N. S. ſub.	18	11		3.120586
Rem. N. Sine of	29	36		4.943860
Logarithm Sine of	29	36		9.693676
Fixed Logarithm add				0.243715
Sum, is Logarithm Sine of	59	58		9.937391

Converted into Time is, 3 Hours 59 Minutes, 52 Seconds + 6 = 9 Hours 59 Minutes 52 Seconds, the Time of the Day.

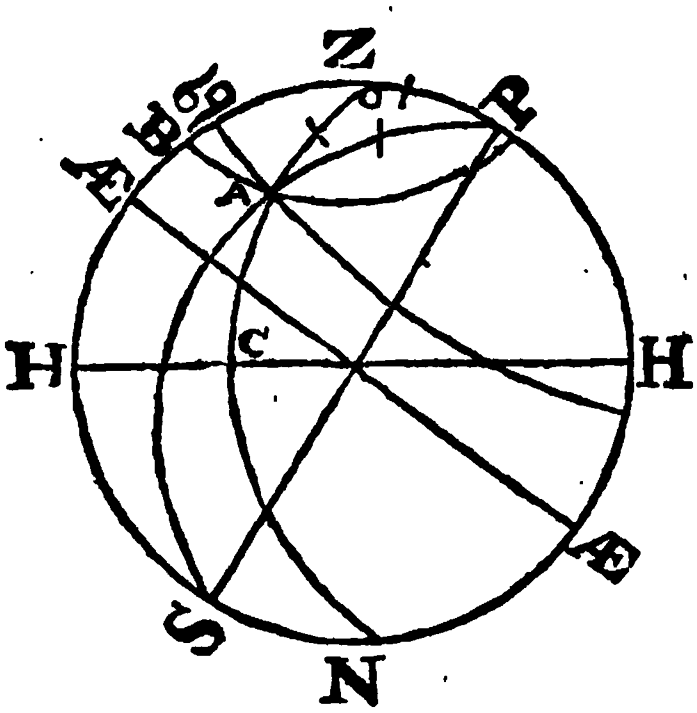
The Hour of the Night may be truly found, by taking the Altitude of any known Star, for there are always given as in the Scheme page 133, A Z the Complement of the Stars Altitude, A P the Complement of the Stars Declination, and Z P the Complement of the Latitude of the Place of Obſervation, to find the Angle at the Pole, or the time from Noon, which Time muſt be ſubtracted from the Time of the Stars ſouthing, if

if the Star be to the East of the Meridian, but added if to the West, the Sun or Difference is the true Hour of the Night. This needs no Example.

PROB. XIX.

Given, the Latitude of the Place, the Sun's Declination and Altitude, to find his Azimuth from the North.

Example. Admit at *London*, I observe the Sun's Altitude 50 Degrees, and his Declination 23 Degrees 29 Minutes North; what is the Azimuth from the North?



With the Chord of 60, draw the primitive Circle, and set off the Latitude of *London* from H to P, and draw the Axis P S, and to it at right Angles the Equinoctial Æ Æ; set off the Altitude 50 Degrees by the Chord from H to B, and draw B P parallel to the Horizon, by the Tangent of 40 Degrees; lay off the Tropic ♋ by the Chord 23 Degrees 29 Minutes, and draw it parallel to the Equinoctial, where it cuts the Parallel of Altitude B P, which is at A; there draw the two oblique Circles P A S and Z A N; then there is formed the oblique angled spheric Triangle A Z P, and in it are all the sides given to find the Angle at the Zenith, which is the Sun's Azimuth from the North.

OPERATION.

	Deg.	Min.
Z P Complement Latitude	38	28
A Z Complement Altitude	40	00
A P Complement Declination	66	31
Sum	144	59
Half	72	29 ½
Complement Latitude sub.	38	28
Difference	34	1 ½
Half Sum	72	29 ½
Complement Altitude sub.	40	00
Difference	32	29 ½

Now Work thus:

	°	′	
Complement Latitude S.	38	28	Co. Ar. 0.206168
Complement Altitude S.	40	00	Co. Ar. 0.191933
Sine Differ. Co. Lat. and half Z	34	1 ½	9.747842
Sine Differ. Co. Alt. and half Z	32	29 ½	9.730117
Sum of the Logarithms			19.876060
Half is Sine of	60	7	9.938030
Double is	120	14	the Sun's Azimuth

from the N. whose Complement to a Semi-circle is 59° 46′ the Sun's Azimuth from the South.

Example 2. At *London* I observed the Sun's Altitude the 9th Day of *January* at 8 in the Morning to be 1 Degr. 14 Min. and declination South 20 Degr. 11 Min. what's the Sun's Azimuth from the North? *Note*, when the Sun's Declination is South, you must add it to 90, to get its Distance from the North Pole.

OPE-

OPERATION.

		Deg.	Min.
Complement	Latitude	38	28
	Altitude	88	46
Sun's Distance from the N. Pole		110	11
	Sum	237	25
	Half	118	42 ½
X	Co. Lat. and half Z	80	14 ½
	Co. Alt. and half Z	29	56 ½

	Deg.	Min.		
Sine Co. Latitude	38	28	Co. Ar.	0.206168
Sine Co. Altitude	88	46	Co. Ar.	0.000100
Sine Difference	80	14 ½		9.993670
Sine Difference	29	56 ½		9.698203
Sum of Logarithms				19.898141
Half is the Sine of	62	47		9.9490705
Doubled, is	125	34,		

the Sun's Azimuth from the North, and its Complement to 180, is the Azimuth from the South 54 Degrees 26 Minutes.

In the next Place, I shall lay down Mr *John Collins*'s his Method of finding the Sun's Azimuth from the East or West, that so the Reader may take which he likes best.

ANALOGY.

As Tangent of half Complement of the Altitude,
To Tangent of half the Sum of Sun or Stars Distance from the elevated Pole, and of the Co. Latitude;
So Tangent of half their Difference,
To Tangent of a fourth Ark.

Then if this fourth Ark be less than half the Co. Altitude, the Azimuth is acute, or less than 90; if more, obtuse, in both Cases get the Difference of the two Arks; but if there be no Difference, the Azimuth is 90 Degrees from the Meridian. Then,

As R.
To t. of the said Ark of Difference;
So t. Latitude,
To S. of the Azimuth from the Prime Vertical or East and West.

EXAM-

EXAMPLE.

		°	′	
Given	Latitude of the Place	51	32	North.
	Altitude of the Sun	25	00	
	Declination South	04	47	

Required the Sun's Azimuth from the North?

OPERATION.

		°	′				
90 + Decl. S. = ☉ dist. à N. Pole		94	47				
Complement Latitude		38	28				
	Z	133	15	$\frac{1}{2}$ = 66	37 t.		10.364121
	X	56	19	$\frac{1}{2}$ = 28	9 t.		9.728412
Sum, fixed for that Declination							20.092533
Altit. 25 Compl. 65° $\frac{1}{2}$ =		32	30 t.			ſub.	9.804187
Tangent of		62	46 t.				10.288346
Difference		30	16 t.				9.766095
Latitude		51	32 t.				10.099913
Azimuth from Eaſt Sine of		47	16 S.				9.866008
		90	00				

Sum 137 16 is the Sun's Azimuth from the North as was required.

The Sun's Azimuth from any of the four Cardinal Points Eaſt, Weſt, North, or South, (for if you have it from any one Point, you have it from the others alſo, by adding 90, or ſubtracting from 180 Degrees, as the Nature of your Queſtion requires) is of very great uſe to the Mariner, and Dialliſt: To the firſt, in aſſiſting him to find the Variation of the Compaſs; and to the other, in getting the Declination of Planes whereon to draw Hour-lines to ſhew the Hour of the Day. In order to the obtaining of which, you muſt get the Horizontal Diſtance of

of the Sun from the Pole of the Plane, and at the same Moment of Time (if possible) take the Sun's Altitude with a large Quadrant accurately divided; both which Instruments may be had of the best sort, and at the lowest Prices, of Mr *John Fowler*, Mathematical Instrument-Maker at the Sign of the *Globe* in *Sweeting's-Alley* by the *Royal Exchange*, *London*. Having gained the Sun's Azimuth, and the Distance of the Sun from the Pole of the Plane, observe these Rules.

1. When you make your Observation of the Horizontal Distance, mark whether the Shadow of the Thread do fall between the South, and that side of the Quadrant which was perpendicular to the Plane; for then, add the Sun's Azimuth from the South to the Horizontal Distance, and that will give you the Declination of the Plane; and the Declination of the Plane is then to the same Point East or West as the Sun is.

2. If the Shadow fall not between them, then the difference between the Sun's Azimuth, and Horizontal Distance, is the Declination of the Plane: And here, if the Azimuth be the greater of the two, then the Plane declines to the same Coast whereon the Sun is; but if the Horizontal distance be the greater, then the Plane declines to the contrary Coast whereon the Sun is.

Note, The Declination thus found, is always accounted from the South; and that all Declinations are accounted from North or South, towards either East or West; and can never exceed 90 Degrees.

Example. Anno 1724, *May* 21, in *London* I observed the Sun's Altitude in the Afternoon with my Astronomical Quadrant, to be 14 Degrees, 40 Minutes, and the Horizontal Distance of the Shadow from the Pole of the Plane to be 22 Degrees, 10 Minutes, between the North and that side of the Quadrant, which was perpendicular to the Plane. What is the Plane's Declination, and to what Coast?

OPE-

OPERATION.

		°	′
Sun's Altitude gives Azimuth	from North	72	40
	from South	107	20
Shadow ſubtract		22	10
Plane's Decl. from South Weſtward		85	10

Example 2. At *London* I obſerved the Sun's Altitude *June* 1, at 8 Morning, to be 36° 26′, and at the ſame time the Shadow of the Horizontal Diſtance between the South and the Perpendicular 18 Degrees, 30 Minutes. What's the Plane's Declination?

OPERATION.

		°	′
Sun's Azimuth from	North	98	14
	South	81	46
Shadow, add		18	30
Decl. from the S. by the E. Northerly		100	16

The Names of all ſorts of Planes are theſe following.

The Horizontal
The North or South Erect Direct
The Erect Decliner
The Recliner or Incliner
The Reclining, Declining
The Convex
The Concave
} Plane.

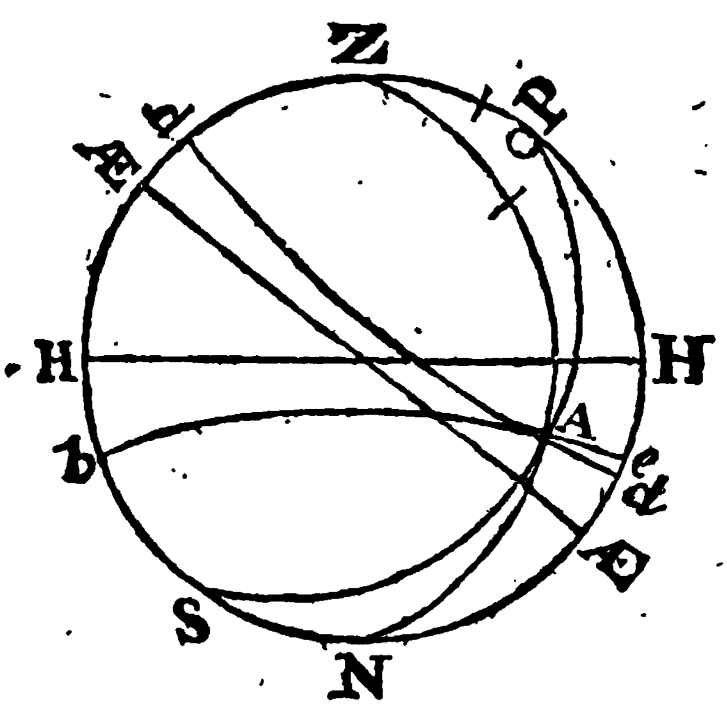
PROB.

PROB. XIX.

Given, the Latitude of the Place, Sun's Declination and Distance from the Zenith, to find the Time of Day-break in the Morning, and Twilight ending in the Evening.

I have told you in the Definitions, that Day-break in the Morning, and also the end of the Evening-twilight is when the Sun is 18 Degrees below the Horizon.

Example. Let it be required in the Parallel of *London* on the 5th Day of *April*, or on the 17th Day of *August*, on which Days the Sun has 10 Degrees North Declination, and the distance from the Zenith is always $18+90=108°$. I demand the true Time of Day-break in the Morning, and the end of the Evening-twilight?



Draw the primitive Circle representing the Meridian of the Place, H H the Horizon, *b e* the Parallel of 18 Degr. under the Horizon, *d d*, the Parallel of the Sun's declination, and A where the Parallel of Declination intersects the Parallel of 18 Degrees; there draw the two oblique Circles Z A N, and P A S, by which is formed the oblique angled spheric Triangle A Z P, in which are given Z P, the Complement of the Latitude 38° 28′, Z A the Sun's distance from the Zenith 108, and P A the Complement of the Declination, or Sun's distance from the north Pole, 80 Degrees, to find the Angle at P, the Time from Noon of the end of the Evening-twilight?

OPERATION, by the 11th Case of oblique Triangles:

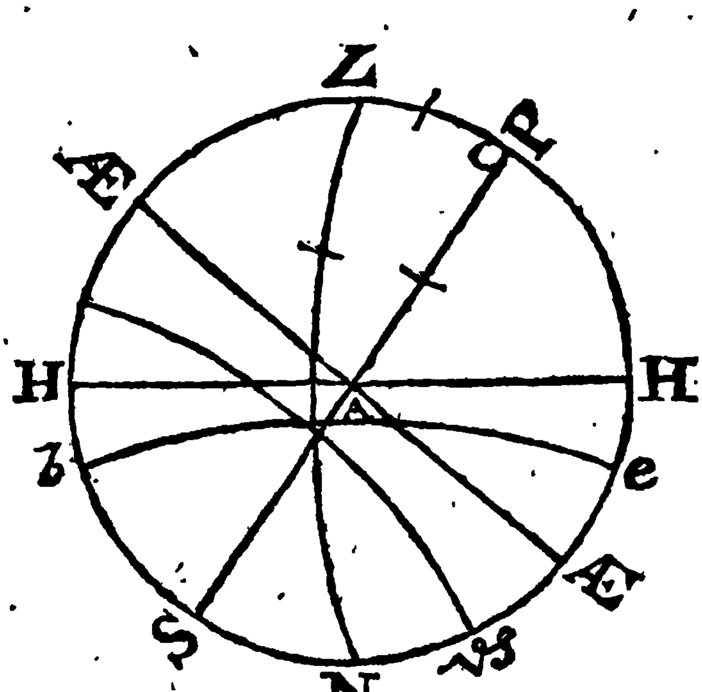
	Deg.	*Min.*			
Z A =	108	0	A P =	80	0
Half	54	6	Z P	38	28
Half + and —	20	46	X	41	32
Z	74	46	half	20	46
X	33	14			

		Deg.	*Min.*
Complement Latit. S.	Co. Ar.	38	28—0.206168
Complement Decl. S.	Co. Ar.	80	00—0.006648
Sum Sine		74	46—9.984466
Difference Sine		33	14—9.738820
Sum of the Logarithms			19.936102
Half Sum is the Sine of		68	18—9.968051
Doubled is		136	36 the Quan-

tity of the Angle at the Pole, which converted into Time, is 9 h. 6′ 24″ the end of Evening-twilight; whose Complement to 12 Hours is 2 h. 53′ 36″ which is the true Time of the Break of Day.

Example 2. What's the Time of Day-break in the Morning, and the end of Twilight in the Evening *Dec.* 10, at *London?*

In the adjacent Diagram H P is the Latitude of *London* 51° 32′, Æ ♑ the Sun's Declination South 23° 29′ + 90 = 113°, 29′ A P the Sun's Distance from the North Pole Z A 108°, the Sun's Distance from the Zenith: And where the Tropic of ♑ intersects the Parallel of 18°, which is at A, there draw the two oblique Circles P A S and Z A N, by which there is formed the oblique angled spherical Triangle P A Z, and in it the three Sides are given to find the Angle at P, the Time from Noon.



OPE-

OPERATION.

	°	′		°	′	
AP	113	29	AZ	108	0	
ZP	38	28	half	54	0	
X	75	1	add and ſub.	37	30 ½	
½	37	30 ½	Z	91	30 ½	Compl. 88° 29′ ½
			X	16	29 ½	

Compl. Latit. S.	38 28		Co. Ar.	0.206168
Compl. ☉ from N. Pole S.	66 31 ½		Co. Ar.	0.037547
Sum, Sine	88 29 ½			9.999849
Difference, Sine	16 29 ½			9.453128
Sum of the Logarithms				19.696692
Half is the Sine of	44 51 26″			9.848346

Doubled is 89 42 the Quantity of the Angle A P Z, which converted into Time, is 5 h. 58′ 48″ the end of Twilight, whoſe Complement to 12 Hours 6 h. 1′ 12″ the time of Day. And if from the end of Twilight you take the true time of the Sun's ſetting is 3 h. 47′ 24″, there will remain 2 h. 11′ 24″, the Duration of Twilight. Or, ſubſtract the true time of the Break of Day from the Sun's riſing, and that will give you the Duration of Twilight as before.

There is a ſecond Method of finding the beginning and ending of Twilight, which I ſhall exemplify in the laſt Queſtion.

OPERATION.

Compl. Latitude	38	28	
Sun's Diſtance from the North Pole	113	28	
Sun's Diſtance from the Zenith	108	0	
Sum	259	56	
Half	129	58	Compl. 50° 2′
Sun's Diſt. from the Zenith ſub.	108	0	
X	21	58	

Now ſay,

	Deg.	Min.	
As Radius	90	00—	10.000000
To C. ſ. Latitude	51	32—	9.793832
So C. ſ. Declination	23	29—	9.962453
To S. fourth Ark	34	47—	9.756285

Say again,

	Deg.	Min.	Sec.	
As S. fourth Ark	34	47		Co. Ar. 0.243764
To S. half Z	50	2		9.884466
So S. X	21	58		9.572949
Sum of the Logarithms				19.701179
Half is C. ſ. of	44	51	26—	9.8305895
Double	89	42	52	the Quantity of the

Angle at P as before; and conſequently the Time is the ſame.

PROB. XX.

Given, the Latitude of the Place, and the Sun's Depreſſion under the Horizon, to find when the ſhorteſt Twilight happens in all the Year. *See* Gregory's, *Aſtronomy, page* 328.

When the Declination of the Sun becomes equal to the difference between the Complement of the Latitude of the Place, and the Depreſſion 18 Degrees, and both North or both South; then there is no Night but Twilight. Thus, in North Latitude 51 Degrees 32 Minutes, its Complement is 38 Degrees 28 Minutes; from which take 18 Degrees the Depreſſion, and there will remain 20 Degrees 28 Minutes the Sun's Declination North, when the total Darkneſs ceaſes in that Latitude; and the two Days that the Sun has that Declination North, are *May* 11, and *July* 10. See the Word *Twilight* in the *Definitions*.

And

And by the Investigation of the *Problem*, I find, that when the Sun has 20 Degrees 28 Minutes South, which he hath on *January* 10, and on *November* 10, that then in the Latitude of 51 Degrees 32 Minutes North, the Day will break at 5 Hours 46 Minutes 8 Seconds, and end at 6 Hours 13 Minutes 52 Seconds; and the Sun sets at 4 Hours 7 Minutes 56 Seconds, therefore the Duration of Twilight is 2 Hours 5 Minutes 56 Seconds; which is shorter than when the Sun was in the Tropic of *Capricorn* by 5 Minutes 31 Seconds. And there is yet a shorter Time of the Duration of Twilight than this, as is plain if you project the Sphere, drawing several Parallels of Declination: And where they intersect the Parallel of 18 Degrees depression, draw great Circles to pass through the Poles; and then if you observe the several Arks of the Equinoctial, intercepted you may there plainly see them to be of an unequal Length; and the shortest in all the Year at *London* will happen *Feb.* 19, and *October* 1, when the Sun has 7 Degrees 2 Minutes Declination South, which is found by this Universal Canon;

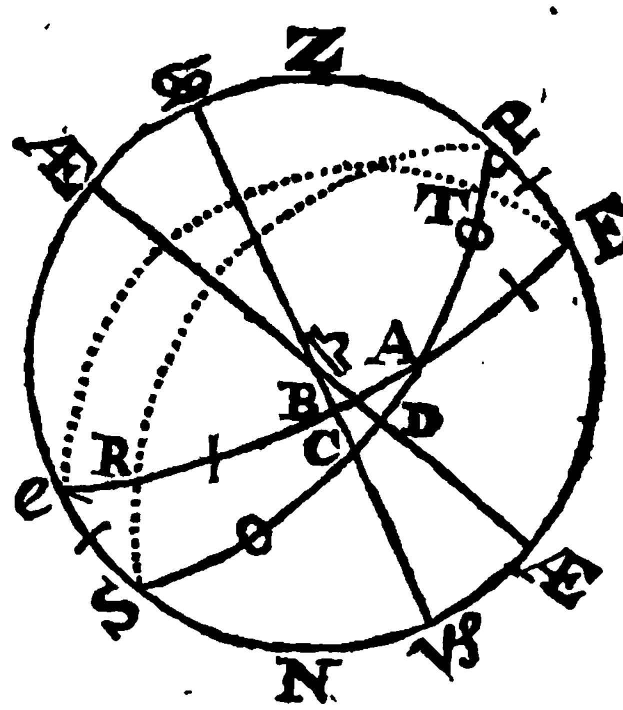
	Min.	Sec.
As Radius	90	00—10.000000
To S. Latitude	51	32— 9.893745
So t. half Depression	9	00— 9.194332
To S. Declination Sun South	7	2— 9.088077

PROB. XXI.

Given, the Longitude and Latitude of a Planet or Star, to find its Declination.

Example. Let it be required to find the Declination of the Star called *Arcturus*, whose Longitude the 1st of *January* in the Year 1727, was ♎ 20 Degrees 24 Minutes 40 Seconds, and Latitude 30 Degrees 57 Minutes North: Draw the Circle Æ S ♑ P to represent the Solstitial Colure, Æ Æ the Equinoctial, P and S its Poles; set off the Chord of 23 Degrees 29 Minutes from Æ to ♋, and draw ♋, ♑, for the Ecliptic, E and *e* its Poles: Then because the Star is in ♎ 20 Degrees 24 Minutes 40 Seconds; that is, 69 Degrees 35 Minutes 20 Seconds from the Solstitial Colure, take the Secant of 69 Degrees 35 Minutes 20 Seconds

20 Seconds, and draw the oblique Circle E A *e* from Pole to Pole. Then by *Prop.* 5. of *Spheric Geometry*, lay down the Stars Latitude from B to A, and thro' that Point; and the Poles of the Equinoctial, draw the Circle of right Ascension P A S; so is there formed the oblique angled spheric Triangle A P E, in which are given, A E the Complement of the Star's Latitude, 59 Degrees 3 Minutes, and P E 23 Degrees 29 Minutes, the



constant Distance of the two Poles, with the included Angle equal to the Longitude of the Star, 20 Degrees 24 Minutes 40 Seconds, to find A P the Complement of the Star's Declination: But for Conveniency of the Solution, I solve it in the Triangle A S *e*, by letting fall the Perpendicular S R: Then the Work will stand thus:

	Deg.	*Min.*	*Sec.*	
As C. t. S *e*	23	29—		10.362044
To Radius	90	0—		10.000000
So C. s. *Angle* S *e* R	69	35—	20	9.542519
To t. *e* R	8	36—	57	9.180475

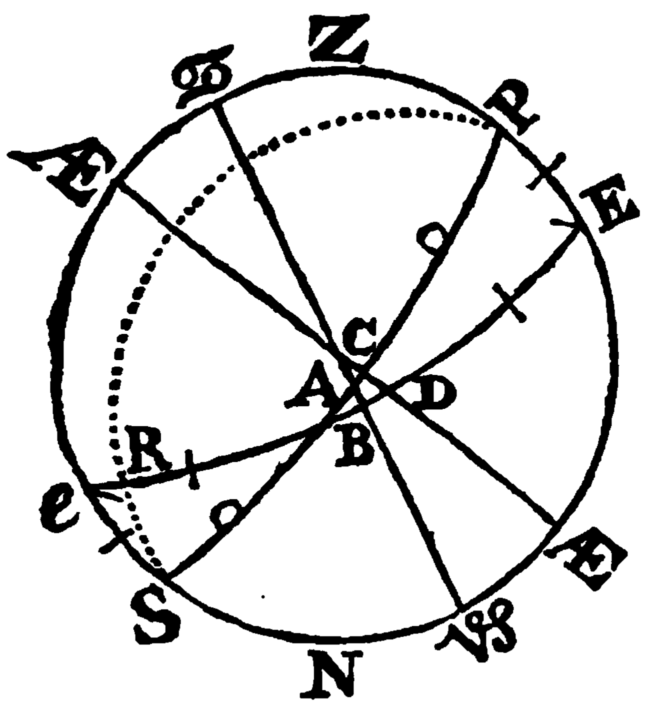
From *e* A	120	57	
Subtract *e* R	8	37	
There Remains R A	112	20	Compl. 67° 40'

Then,

	°	'		
As C. s. *e* R	8	37	Co. Ar.	0.004929
To C. s. R A	67	40		9.579777
So C. s. *e* S	23	29		9.962453
To S. D A Decl.	20	38	25	9.547159

Example.

Example 2. Let the Declination of the bright Star, called the *Virgin's Spike*, be sought, whose Longitude, is ♎ 20 Degrees 2 Minutes 10 Seconds, and Latitude 2 Degrees 2 Minutes South.



Draw the Solstitial Colure P Æ S ♑ with the Chord of 60 Degrees to any convenient Radius, Æ Æ the Equinoctial, P and S its Poles; set off the Chord of 29 Degrees 29 Minutes from Æ to ♋, and draw ♋, ♑, for the Ecliptic, E and *e* its Poles. Then because the Star is 69 Degrees 57 Min. 50 Seconds from the Solstitial Colure, take the Secant of 69° 57′ 50″, and draw the Circle of Longitude E A *e*, on the Circle of Longitude; set off the Star's Latitude South from B to A, and draw the Circle of right Ascension P A S; then in the oblique angled spheric Triangle A *e* S, are given, *e* S, the Distance of the two Poles 23° 29′, *e* A the Complement of the Stars Latitude 87 Degrees 58 Minutes with the included Angle S *e* A, the Longitude of the Star from the Solstitial Colure, 69 Degrees 57 Minutes 50 Seconds, to find S A, the Complement of the Star's Declination.

OPERATION.

	Deg.	*Min.*	*Sec.*	
As C. t. S *e*	23	29	0	—10.362544
To Radius	90	0	0	—10.000000
So Co. f. *Angle* S *e* R	69	57	50	— 9.534803
To t. *e* R fubt.	8	27	59	— 9.172759
From *e* A	87	58	00	
Remains R A	79	30	1	

Then

Then,

	Deg.	Min.	Sec.		
As C. ſ. e R	8	27	59	Co. Ar.	0.005339
To C. ſ. R A	79	30	1		9.260622
So C. ſ. e S	23	29	0		9.962453
To S. A C Decl. S.	9	44	30		9.228414

The ſame by Tranſpoſition, it will always hold.

	Deg.	Min.	Sec.	
As Radius	90	0	0--	10.000000
To S. Stars Longitude from ♎	20	2	10--	9.534803
So t. of the Obliquity	23	29	0--	9.937956
To t. of the firſt Ark	8	27	59--	9.172759

Now obſerve,

If the Declination ſought be in the		
	Northern Signs and	North Latitude, Sub. the firſt Arch from Complement of the Star's Latitude, and there remains the ſecond Arch.
		South Latitude, Add the firſt Ark found as above to the Complement of the Star's Latitude, the Sum is the ſecond Arch.
	Southern Signs and	South Latitude, Subtract the firſt Arch from the Complement of the Star's Latitude, and there remains the ſecond Arch.
		North Latitude, add the firſt Arch found to the Complement of the Star's Latitude, and the Sum is the ſecond Arch.

Note, That north Geclination, and north Latitude, is the ſame with ſouth Declination and ſouth Latitude; and ſouth Declination and north Latitude, is the ſame with north Declination and ſouth Latitude: So that the two following Examples of the Moon are all the Varieties that can happen.

EXAM-

EXAMPLE.

	Deg.	*Min.*
From a Quadrant	90	0
Sub. the Star's Latitude	2	2
Rests the Complement	87	58.

Then because the Star is in a southern Sign and south Latitude, (according to the third Canon above) subtract the first Arch 8 Degr. 27 Min. 59 Sec. from the Complement of the Star's Latitude 87 Degr. 58 Min. and there remains 79 Degr. 30 Min. 1 Sec. the second Arch. Then the second Analogy is,

	°	′	″		
As C. s. first Arch	8	27	59	Co. Ar.	0.005339
To C. s. of the second	79	30	1		9.260522
So C. s. Obliq. Ecliptic	23	29	0		9.962453
To S. Decl. South	9	44	30		9.228314

Example 3. Admit the Moon is ♊ 41 degr. 28 Min. with 5 Degr. 2 Minutes North Latitude: What's her Declination?

OPERATION.

	Deg.	*Min.*	
As Radius	90	0	10.000000
To S. of her Long. from ♈	71	28	9.976872
So T. Obliquity Ecliptic	23	29	9.637956
To t. first Ark sub.	22	22	9.614828
Complement ☾'s Latitude	84	58	By the 1*st* Rule.
Remains second Arch	62	35	

Now say,

	Deg.	*Min.*		
As C. s. first Arch	22	23	Co. Ar.	0.034019
To C. s. second	62	35		9.663190
So C. s. Obliquity Elciptic	23	29		9.962453
To S. Declination North	27	10		9.659662

Example 4: Let the Moon be in ♊ 11 degr. 28 min. a before; and 5 degr. 2 min. south Latitude; Then what's her Declination?

OPERATION.

	Deg.	Min.
As Radius	90	00—10.000000
To S. of her Longitude	71	28— 9.976872
So t. Obliquity Ecliptic	23	29— 9.637956
To t. first Ark	22	23— 9.614828
Compl. ☽'s Latit. add	84	58— By the 2d Rule.
Z is second Ark	107	21—Compl. 72° 39′

Now say,

	Deg,	Min.	
As C. f. first Arch	22	23	Co. Ar. 0.034019
To C. f. second	72	39	9.474519
So C. f. Obliquity Ecliptic	23	29	9.962453
To Sine Decl. North	17	12	9.470991

By these two last Operations you may see what special Regard ought to be had to the Latitude of the Planets and Stars: For although their Longitudes be the same, yet by Reason of their different Latitudes, they will rise, south, and set at different Times; but always get their true Declination, and then you cannot miss of the true Time. To know what Stars Declination encrease, and what decrease.

Observe, if the Longitude of the Star be between the beginning of *Capricorn*, to the beginning of *Cancer*.

Then { North Declination increases / South Declination decreases } till it comes to Equinoctial, and then it increases.

But between ♋ and ♑ { North Decl. decreases. / South Declination increases.

PROP.

PROP. XXII.

Given the Longitude, Latitude, and Declination of a Planet or Star, to find their Right Ascension.

Example. Let the Right Aſcenſion of the Star *Arcturus* be required, whoſe

		Deg.	Min.	Sec.	
Longitude	is	♎ 20	24	40	
Latitude	is	30	57	00	North.
Declination	is	20	38	25	North.

In the firſt Scheme of the laſt Problem, and in the Oblique-angled Spheric Triangle A P E are given, A E P, the Longitude from ♎; A E the Complement of the Stars Latitude 59 degr. 3 min. and A P, the Complement of the Declination 69 degr. 21 min. 35 ſeconds, to find the Angle at P = ♎ D from ♎.

OPERATION.

	Deg.	Min.	Sec.		
As C. ſ. Declination	20	38	25	Co. Ar.	0.028812
To C. ſ. Longitude	20	24	40		9.971839
So C. ſ. Latitude	30	57	00		9.933293
To C. ſ. Right Aſcenſion	30	48	23		9.933944
Add	180	00	00		
Right Aſcenſion is	210	48	23	*Jan.* 1, 1727.	

The reaſon why your add a Semicircle, you have in Prob. 3. the ſame alſo may be found by the 11th Caſe of Oblique-angled ſpheric Triangles: for in the ſame Triangle A E P, all the Sides are known, and required to find the Angle A P E, the quantity of which is the Star's Right Aſcenſion from *Capricorn*.

Given,

Compl. Decl. A P	69	21	35	Required *Angle* APE,
Compl. Lat. EA	59	3	0	
Diſt. of the two Poles P E	23	29	0	

OPERA-

OPERATION.

		Deg.	Min.	Sec.
Sides including the required *Angle*	A P	69	21	35
	E P	23	29	0
	X	45	52	35
	½ =	22	56	17

Side Opposite to required Angle is A E	59°	3′			
Half	29	31	30″		
Half Z Sides	22	56	17		
Z	52	27	47		
X	6	35	13		
S. Comp. Decl. AP	69	21	35	Co. Ar.	0.028812
S. Dist. Poles P E	23	29	0	Co. Ar.	0.399591
S. Z	52	27	47		9.399591
S. X	6	35	13		9.059604
Sum of the Logarithms					19.387259
Half is the Sine of	29	36	5		9.6936295

Doubled is 59 12 10 whose Compl. to 270 is 210° 47′ 50″.

Example 2. What's the Right Ascension of the Star call'd the *Virgin's Spike*; its

		Deg.	Min.	Sec.	
Longitude	being	♎ 20	2	10	
Latitude		2	2	0	South?
Declination		9	44	30	South;

OPERATION.

	Deg.	Min.	Sec.		
As C. f. Declination	9	44	30	Co. Ar.	0.036309
To C. f. Longitude	20	2	10		9.972885
So C. f. Latitude	2	2	0		9.999726
To C. f. Right Ascension	17	42	22		9.978920
Add	180	00	00		
Right Ascension is	197	42	28.	*Jan.* 1, 1727	

PROB.

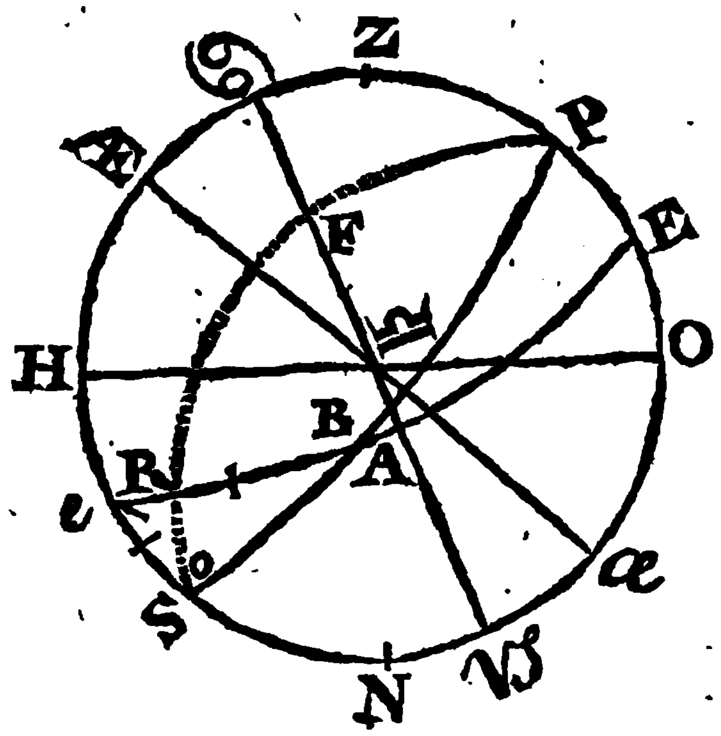
PROB. XXIII.

Given, the Longitude and Latitude of a Star or Planet, to find the Right Ascension.

Example. Let the right Ascension of the Star called the *Virgin's Spike*, be required, whose Longitude is ♎ 20 Degrees 2 Min. 10 Sec. and Latitude 2 Deg. 2 Min. South.

To Project this Question.

1. To any convenient Radius, draw the primitive Circle H Z O N, which is also the Solstitial Colure.
2. Draw H O for the Horizon.
3. Take the Chord of 38° 28′ the Co. Lat. of *London*, and set it from H to Æ, and draw Æ Æ for the Equinoctial.
4. Set the Chord of 23° 29′ (the Obliquitity) from Æ to ♋, and draw ♋, ♑, for the Ecliptic.
5. Make Z P = H Æ 38° 28′, and P E = Æ ♋ = 23° 29′.
6. Set the Stars Longitude 20° 2′ upon the Ecliptic from ♋ to A by help of the half Tangents, and through the three given Points E A *e*, draw the Circle of Longitude.
7. Through the three given Points P A S, draw the Hour-circle P A S, and 'tis done. Then in the oblique angled spheric Triangle A S *e* are known. 1. A *e* the Complement of the Stars Latitude = 87 58. 2. E S the constant Distance of the two Poles, *viz.* of the Ecliptic and Equinoctial = 23° 29′. And *Lastly*, The Angle S *e* A, which is the Longitude of the Star from the Solstitial Colure, to find the Angle *e* S A, the right Ascension from the Solstitial Colure.



Now

Now the *Prob.* being projected, here are given two Sides and the Angle included, to find the other two Angles which I shall give first in Words at length, and then the Operation at large.

Take half the Sum, and half the Difference of the two given Sides, and also half the given Angle, and Say

1. As the Sine of half the Sum,
To the Sine of half the Difference of the two given Sides.
So is the Co. Tangent of half the given Angle,
To the Tangent of an Arch.

2. As the Co. Sine of half the Sum of the given Sides,
To the Co. Sine of their Difference,
So is the Co. Tangent of half the given Angle,
To the Tangent of an Arch: This added to the Angle, or Arch found by the first Analogy, gives the greater Angle (in this Question is the Angle A S *e*) and subt. gives the lesser Angle, *viz.* *e* A S.

OPERATION.

	Deg.	*Min.*						
e B =	87	58						
e S =	23	29						
				Deg.	*Min.*	*Sec.*		
Z =	111	27 ½		= 55	43	30	S. Co. Ar.	0.0828391
X =	64	29 ½		= 32	14	30	S.	9.7271274
< *e* =	69	57	50½	= 34	58	55	C. t.	10.1550645
To the Arch				42	41	45	t.	9.9650310

Now say,

	Deg.	*Min.*	*Sec.*		
As C s.	55	43	30	Co. Ar.	0.2493699
To C s.	32	14	30		9.9272705
So C t.	34	58	55		10.1550645
To t.	65	01	09		10.3317053
+ And —	42	41	45		
Sum =	107	42	54	= < S *e* B	
Add Æ =	90	00	00		
Z = ☉ R A	197	42	54	From ♈	
X =	22	19	24	= < S B *e*.	

Note,

Note, If the Place of a Star be a few Degrees in *Aries*, and great North Latitude, as the Head of *Andromeda*, whose Longitude this present Year 1742, is ♈ 10° 42′ 13″, with 25° 41′ North Latitude, if we work for the right Ascension according to the above Directions, we shall find the first Arch to be only 21° 7′, which is less than 23° 29′ by 2° 22′, therefore the first Arch must be Subtracted from the Obliquity of the Ecliptic 23° 29′, and the Remainder 2° 22′ is the second Angle; and the fourth Angle will come out 1° 14′ which must be taken out of 360°, and the Remainder 358° 46′ is the Stars Right Ascension to the Year above.

Or by this.

ANALOGY.

	Deg.	*Min.*	*Sec.*	
As Radius	90	0	0	—10.000000
To S. Longitude from ♎	20	2	10	— 9.534803
So C. t. Latitude of *Spica*	2	2	00	—11.449732
To t. of the first Ark	84	5	02	—10.984535

Now this General Rule is to be observed;

viz.

If the Longit. of the Star be		And Latit.		° ′
	♈ ♉ ♊ ♋ ♌ ♍		North subt. South add	23 29, to, or from the first Angle, the Z or X is the second Arch.
	♎ ♏ ♐ ♑ ♒ ♓		North add South subt.	

EXAMPLE.

Here the Star is in ♎, and Latitude South; therefore

	Deg.	*Min.*	*Sec.*
From the first Arch	84	5	2
Subt. the Obliquity Ecliptic	23	29	0
Remains the second Angle	60	36	2

Now

Now say,

	Deg.	Min.	Sec.		
As S. of the first Arch	84	5	2	Co. Ar.	0.002319
To S. Second	60	36	2		9.940127
So t. of the Longitude	20	2	10		9.561917
To t. R. A. from ♎	17	42	52		9.504363
Add a Semi-circle	180	00	00		
Z. R. A. from ♈	197	42	52 as before.		

And after this manner are the Tables of Right Ascensions in Time in this Treatise Calculated. In which may be observed that a Planet or Star having Latitude

North in	♑	♒	♓	♈	♉	♊	The Right Ascension is di-
South in	♋	♌	♍	♎	♏	♐	

minished, and consequently the Star comes sooner to the Meridian than if it were in the Ecliptic.

But when the Latitude of the Star is

North is	♋	♌	♍	♎	♏	♐	The right Ascension is in-
South in	♑	♒	♓	♈	♉	♊	

creased, by which a Planet comes later to the Meridian than if it were simply in the Ecliptic.

PROB. XXIV.

Given, the Right Ascension and Declination of a Star or Planet, to find its Longitude and Latitude.

This Problem is only a Conversion of the two last; for in the same Triangle A E P, Scheme page 133, there are given P E the constant Distance of the two Poles 23 Degrees 29 Minutes, and A P the Complement of the Declination, and the included Angle A P E the right Ascension from *Capricorn*, to find A E, the Complement of the Latitude of the Star, and the Angle A E P, its Longitude?

Example. The right Ascension and Declination of *Arcturus*, is 210° 48′ 23″ and 20° 38′ 25″, What's its Longitude and Latitude?

First,

First, For the Latitude, or its Complement A E,

Let fall the Perpendicular E T; than in the right angled spheric Triangle E T P.

	Deg.	Min.	
As C. t. E P	23	29	—10.362044
To Radius	90	0	—10.000000
So C. f. *Angle* T P E, R. A. from ♑	59	12	— 9.709306
To t. T P	12	33	— 9.347262

Or, by Transposition, say,

	Deg.	Min.	
As Radius	90	0	—10.000000
To t, E P	23	29	— 9.637956
So C. f. *Angle* T P E	59	12	— 9.709306
To t, T P fubt.	12	33	— 9.347262
From A P	69	22	
Remains T A	56	49	

Now fay,

	Deg.	Min.	
As C. f. firft Arch P T	12	33	Co. Ar. 0.010403
To C. f. fecond T A	56	49	9.738241
So C. f. P E = Obliquity	23	29	9.962453
To S. Latitude B A	30	57	9.711097

Secondly, For the Longitude or Angle A E P. Now all the Sides are known and the Angle at P; therefore by the firft Cafe of oblique angled fpherical Triangles, it will hold.

	Deg.	Min.	
As S. A E Co. Latitude	59	3	Co. Ar. 0.066707
To S. *Angle* P. R. A. from ♑	59	12	9.933973
So S. A P. Co. Declination	69	22	9.971208
To S. *Angle* E fubt.	69	36	9.971888
From	180	0	
Angle A E P	110	24	
Sub. ♋	90	0	
Remains Longitude in ♎	20	24	

Y Or,

Or, if I had substracted 69 Degrees 22 Minutes from 90 Degrees, it would have given me the same thing.

These three last Problems are of excellent use in making Astronomical Observation, as the young Student will presently perceive, when he is a little acquainted with this sublime Study. For by the 21st and 22d you may find the right Ascensions and Declinations of all, or any of the fixed Stars in the following Catalogue, which R A. being reduced into Time; will be of excellent use to find the Hour of the Night by the Stars; as I shall shew in its proper Place.

A TABLE

A TABLE *of the Right Ascensions, reduced into Time, and Declinations of* 42 *Eminent fixed Stars for the Year* 1727, *being of use to find the Hour of the Night,*

Stars NAMES.	Declination. °	′	″	R. A. in Motion °	′	″	R. A in Time. H.	′	″
IN the Breast of *Cassiopeia, Scheder,*	55	2	N 20	6	18	30	0	25	14
The Bright Star in the Tail of the *Whale,*	19	29	S 30	7	26	50	0	29	47
Pole Star,	87	54	N 0	9	10	26	0	36	10
The Bright Star of *Aries,*	22	9	N 00	27	56	40	1	51	47
In the Jaw of the *Whale, Mandibula,*	2	59	32	42	00	00	2	48	0
Head of *Medusa, Algol,*	39	53	00	42	36	45	2	50	27
The bright Side of *Perseus,*	48	51	40	46	14	30	3	4	58
Brightest of the 7 Stars *Pleiades,*	23	14	00	52	50	00	3	31	20
The South Eye of the *Bull, Aldebaran,*	15	55	46	65	3	00	4	20	12
In the *Goat, Capella,*	45	41	50	74	7	30	4	56	30
The bright Star in the left Foot of *Orion, Regel,*	8	33	S 12	75	21	00	5	1	24
North Horn of the *Bull,*	28	20	N 51	77	14	00	5	8	56
The Left Shoulder of *Orion,*	6	4	28	77	37	25	5	10	29
South Horn of the *Bull,*	20	56	45	80	19	20	5	21	18
The middle Star in *Orion's* Belt,	1	25	S 0	80	34	31	5	22	18
The last in *Orion's* Belt,	2	7	12	81	44	40	5	26	59
Right Shoulder of *Orion,*	7	19	N 26	85	4	38	5	40	18
In the Great *Dog's* Mouth, *Syrius,*	16	20	S 58	98	16	40	6	33	7
Castor, or the *Head Northern Twin,*	32	27	N 0	109	15	50	7	17	3
Procyron, the *Little Dog,*	5	54	15	111	14	12	7	24	57
Pollux, or the *Southern Twin,*	28	39	14	112	7	39	7	28	30
The Heart of *Hydra,*	7	29	S 0	138	31	20	9	14	5
The *Lion's* Heart, *Regulus,*	13	17	N 0	148	26	7	9	53	44
The Southermost of the two preced. ✱ in □ *Great Bear,*	57	50	36	161	16	26	10	45	6
The Northernmost of them,	63	13	40	161	37	50	10	46	31
The Tail of the *Lion, Deneb.*	16	5	30	173	46	10	11	35	5
The North of the 2 following in the □ *Great Bear,*	58	34	28	180	27	40	12	1	47
The first in the Tail of the *Great Bear,*	57	30	0	190	23	00	12	41	32

The

The TABLE continued.

Stars NAMES.	Declination. °	′	″	R. A. in Motion. °	′	″	R. A. in Time. H.	′	″
In the North-Wing of the *Virgin Vindematrix*,	12	25	40	192	30	52	12	46	3
The *Virgin's Spike*,	9	44	S 36	197	42	28	13	10	50
The Middle of the three in the Tail of the *Great Bear*,	56	22	N 36	197	44	0	13	10	56
The last but one in the Tail of *Hydra*,	21	43	S 0	196	2	27	13	4	10
The last of the three in the Tail of *Great Bear*,	50	42	N 0	204	11	50	13	36	47
In the following Shoulder of the *Centaur*,	34	37	50	207	39	32	13	50	38
Arcturus,	20	38	25	210	48	23	14	3	13
The *Scorpion's* Heart, *Antares*.	25	47	S 30	243	10	20	16	12	40
The brightest in the *Dragon's* Head,	51	32	N 0	267	35	45	17	50	23
The brighest Star in the *Harp*,	38	33	10	267	35	45	18	27	37
The brightest in the *Eagle*,	8	10	15	276	54	20	19	37	20
The Mouth of the Southern *Fish Fomahaut*,	31	3	S 30	340	34	59	22	42	20
In *Pegasus*, the *Flying-Horse*, *Scheat*,	26	35	N 52	342	37	20	22	50	29
The Head of *Andromeda*,	27	34	22	358	33	30	23	54	14

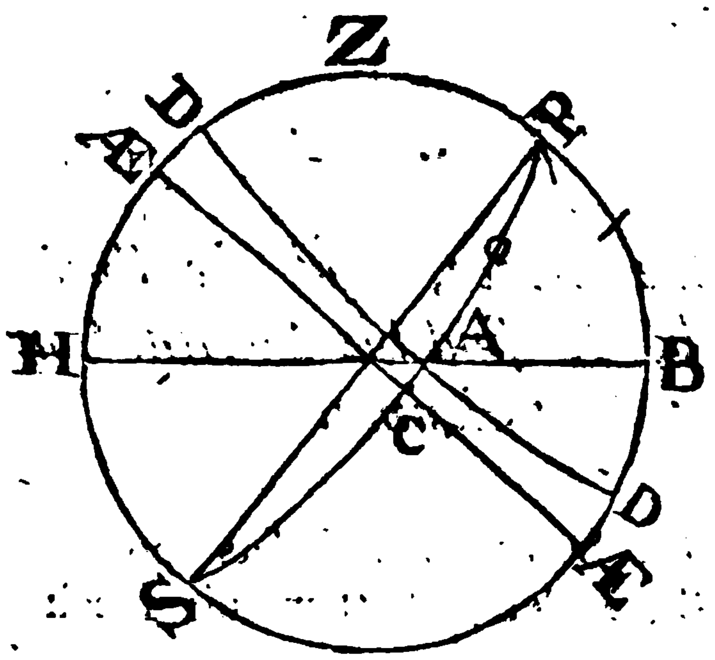
The Semidiurnal Arch at *London* of *Arcturus* is 7 h. 53′ 14″.

PROB

PROB. XXV.

Given, the Latitude of the Place, and the Hour of the Sun's setting, to find its Declination.

Example. At *London* when the Sun apparently rises at 5, and sets at 7 o'Clock, I then demand its Declination?



Draw P H S B, to represent the Solstitial Colure, H B the Horizon, Æ Æ the Equinoctial; by help of the Lines of Chords on the Sector set of the Pole's Elevation from B to P 51 Degr. 32 Minutes; then because the given Hour is between Six o'Clock and Midnight, *viz.* 5 Hours = 75 Degrees, take the Secant of 75, and draw P, A, S, the given Hour-circle, and where it cuts the Horizon which is at A, there the Parallel of the Sun's Declination D D for that Day must also intersect it: Then in the right angled spherical Triangle A B P, there are given B P, the Pole's Elevation 51 Degrees 32 Minutes, and the *Angle* A P B 75 Degrees, to find A P, the Complement of the Declination.

OPERATION.

	Deg.	Min.	
As t. B P the Lat.	51	32	—10.099913
To Radius	90	00	—10.000000
So C. s. *Angle* A P B	75	00	— 9.412996
To C. t. A P	78	23	— 9.313083 whose Comp. is 11° 37′

Or,

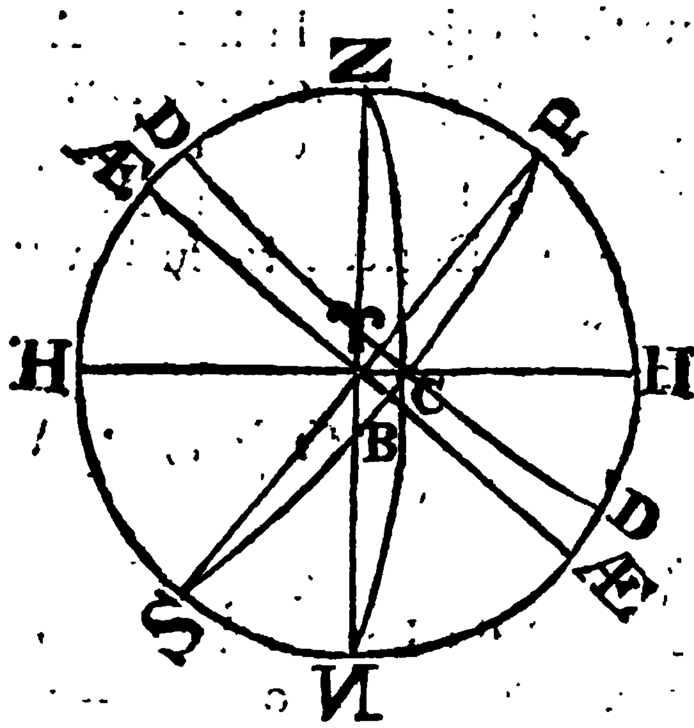
Or, by *Transposition*	Deg.	Min.		☉ Sets Hours.	Declination. °	'	
				4	21	40	South
As Radius	90	0	10.000000	5	11	37	
To C. t. B. P. the Lat.	51	32	9.900086	6	0	00	
So C. s. *Angle* A P B	75	00	9.412996	7	11	37	North
To t. CA the Decl. N.	11	37	9.313085	8	21	40	

And after the same manner have I found the Declination as in this Table on the right Head.

PROB. XXVI.

Given, the Latitude of the Place, and the Sun's Azimuth from the South, to find his Declination when he rises and sets upon that Azimuth.

Example. At *London*, when the Sun rises and sets upon the 100th Azimuth from the South, I demand then his Declination?



Draw the Solstitial Colure ZHNA, set off the Latitude from H to P, and from Z Æ, draw Æ Æ for the Equinoctial; and because the given Azimuth is a 100 from the South, that is 80 from the North, take the Secant of 80, and draw the Azimuth Z *c* N, where it intersects the Horizon, which is at *c*; thro' that Intersection draw the Hour-circles P *c* S; then in the little Triangle ♈ B *c* are given ♈ *c*, the Azimuth from the East or West 10 Degrees, and the Angle B ♈ *c* = the Complement of the Latitude 38 Degrees 28 Minutes, to find the Declination B *c*.

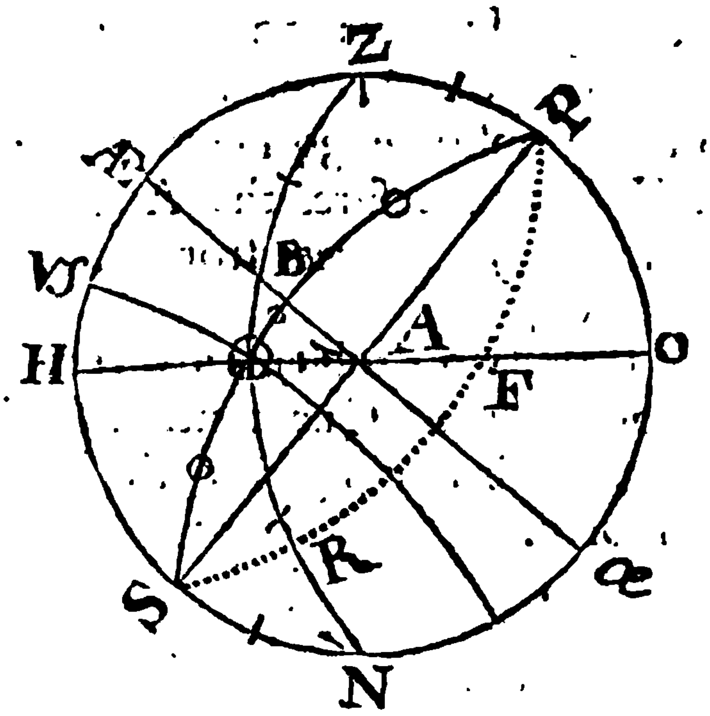
ANALOGY

ANALOGY.

	Deg.	Min.	
As Radius	90	00—	10.000000
To S. ♈ c Azimuth from E. or W.	10	00—	9.239670
So S. *Angle* B ♈ c, Co. Latitude	38	28—	9.793832
To S. B c Declination North	6	12—	9.033502

Example 2. What Declination has the Sun when he sets at *London* upon the 50 Degr. 10 Min. Azimuth from South?

This may be solved in either the Triangle C Z P, or in A B C, or in C S N, but more readily in the latter.



In the oblique spherical Triangle ☉ S N, are known, ☉ N = 90°, S N = 38° 28′, and the Angle S N ☉ = 50° 10′, to find S ☉, the Co. Declination.

OPERATION.

	°	′		
As C. t. S N	38	28		10.099913
To Radius	90	00		10.000000
So C S < S N C	50	10		9.806557
To t. N R	26	58		9.706644
From ☉ N	90	00		
Rem. R ☉ =	63	2		
As C S. N R =	26	58	Co. Ar.	0.049991
To C S. ☉ R	63	2		9.656550
So C S. N S =	38	28		9.893745
To C S. S ☉ =	66	31		9.600245

Then S B = 90 — 66 31 = ☉ B the Declination S 23° 29′.

ANALOGY

ANALOGY.

	Deg.	Min.	
As Radius	90	00	10.000000
To C. f. Azimuth from the South ☉ A	50	10	9.816557
So C. f. Latitude = B A C	51	32	9.793832
To S. Declination South ☉ B	23	29	9.600389

By which Calculations it appears that when the Sun is in the Tropic of *Capricorn*, his Azimuth from the South when he riseth and setteth, is 50 Degrees 10 Minutes, and its Complement to a Quadrant is the Azimuth from the East and West Points, equal to the Amplitude 39 Degrees 50 Minutes because this Arch of the Horizon measures the Angle at the Zenith, it being at the Distance of 90 Degrees from it.

Hence, because these two Problems are very useful to delineate the Hour-lines upon *Gunter*'s Quadrant, I shall here insert all the Requisites thereunto belonging for the Latitude of 51 Degrees 32 Minutes North.

A TABLE

A TABLE *of the Sun's Declination to every 5th Day of the Month for the Year* 1727, *for Inscribing the Months.*

Months.	1 °	1 ′	5 °	5 ′	10 °	10 ′	15 °	15 ′	20 °	20 ′	25 °	25 ′	30 °	30 ′
January	21 S	42	21	2	19	58	18	47	17 S	27	16	00	14	25
February	13	46	12	25	10	38	08	48	06	54	04	58	00	00
March	03	25	01	50	00 N	08	02	07	04 N	04	05	59	07	51
April	08 N	35	10	02	11	46	13	26	15	00	16	28	17	49
May	18	4	19	03	20	08	21	05	21	54	22	32	23	01
June	23	10	23	22	23	29	23	25	23	11	22	47	22	12
July	22	4	21	29	20	36	19	34	18	24	17	07	15	43
August	15	8	13	54	12	17	10	34	08	48	06	58	05	05
September	04	20	02	47	00	51	01 S	07	03 S	04	05	00	06	55
October	07 S	18	08	48	10	37	12	22	14	03	15	38	17	07
Novemb.	17	40	18	43	19	54	20	57	21	49	22	31	23	02
December	23	6	23	21	23	29	23	25	23	09	22	42	22	03

A TABLE *of the Sun's Meridian Altitude to every 5th Day for the Latitude of 51° 32′ North.*

Months.	1 °	1 ′	5 °	5 ′	10 °	10 ′	15 °	15 ′	20 °	20 ′	25 °	25 ′	30 °	30 ′
January	16	46	17	26	18	30	19	41	21	01	22	28	24	03
February	24	42	26	03	27	50	29	40	31	34	33	30	00	00
March	35	3	36	38	38	36	40	35	42	32	44	27	46	19
April	47	3	48	30	50	14	51	54	53	28	54	56	56	17
May	56	32	57	31	58	36	59	33	60	22	61	00	61	29
June	61	38	61	50	61	57	61	53	61	39	61	15	60	40
July	60	32	59	57	59	04	58	02	56	52	55	35	54	11
August	53	36	52	22	50	45	49	02	47	16	45	26	43	33
September	42	48	41	15	39	19	37	21	35	24	33	28	31	33
October	31	10	29	40	27	51	26	06	24	25	22	50	21	21
Novemb.	20	48	19	45	18	34	17	31	16	39	15	57	15	26
December	15	22	15	07	14	59	15	03	15	19	15	46	16	25

North Declinations added, and South subtracted, to, or from the Elevation of the Equinoctial, give the Meridian Altitude.

A

A TABLE *of the Sun's Altitude at every Hour when he is in the Equator and Tropics, Latitude* 51 *Degrees* 32 *Minutes North, for drawing the Hour-lines, on* Gunter's *Quadrant.*

Ho.		Equinoctial By *Prob.* 14				Tropics. ♑		♋		
		°	′	°	′	°	′	°	′	
12		0	0	38	28	61	57	14	59	By *Prob.* 16.
11	1	15	0	36	56	59	50	13	54	
10	2	30	0	32	36	53	45	10	30	
9	3	45	0	26	6	45	41	5	17	
8	4	60	0	18	7	36	40			
7	5	75	0	9	16	27	22			
6	6	90	0	0	0	18	10			By *Prob.* 13.
5	7					9	27			By *Prob.* 16.
4	8					1	31			

See the TABLE of the Sun's Rising and Setting at *London*.

A TABLE *of Right Ascension to every 5th Deg. of Longitude for dividing the Equinoctial in the Quadrant.*

⊙ Long.	♈ °	♈ '	♉ °	♉ '	♊ °	♊ '	♋ °	♋ '	♌ °	♌ '	♍ °	♍ '
0	0	0	27	54	57	48	90	0	122	12	152	6
5	4	35	32	42	63	3	97	27	127	22	156	51
10	9	11	37	34	68	21	100	53	132	28	161	33
15	13	48	42	21	73	43	106	17	137	29	166	12
20	18	27	47	32	79	7	111	39	142	26	170	49
25	23	9	52	38	84	33	116	57	147	18	175	25
30	27	54	57	48	90	0	122	12	152	6	180	0

⊙ Long.	♎ °	♎ '	♏ °	♏ '	♐ °	♐ '	♑ °	♑ '	♒ °	♒ '	♓ °	♓ '
0	180	0	207	54	237	48	270	0	302	12	332	6
5	184	35	212	42	243	3	275	27	307	22	336	51
10	189	11	217	34	248	21	280	53	312	28	341	33
15	193	48	222	21	253	43	286	17	317	29	346	12
20	198	27	227	32	259	7	291	39	322	26	350	49
25	203	9	232	38	264	33	296	57	327	18	355	25
30	207	54	237	48	270	0	302	12	332	6	360	00

A TABLE

A TABLE *shewing the Ascensional Difference to every Degree of the Sun's Declination for the Latitude of* 51 *Degrees* 32 *Minutes North. Calculated by Problem* 5.

Decl. Sun.	Ascensional Difference.	
1	1	16
2	2	31
3	3	47
4	5	3
5	6	19
6	7	36
7	8	53
8	10	11
9	11	29
10	12	49
11	14	9
12	15	30
13	16	53
14	18	17
15	19	42
16	21	8
17	22	37
18	24	7
19	25	40
20	27	15
21	28	52
22	30	32
23	32	16
23 29	33	9

To Draw the Azimuth in the Quadrant.

For this purpose you must first calculate a Table shewing the Sun's Altitude above the Horizon when he is in the Equinoctial Tropics, and some other intermediate Parallels of Declinations at every 5th or 10th Azimuth.

Thus, suppose the Latitude 51° 32′ North and the Sun in the Equinoctial on the 80th Azimuth from the South; What's the Altitude?

ANALOGY.

	°	′	
As Radius	90	00—	10.000000
To C. t. of the Latitude	51	32—	9.900086
So C. s. of Azimuth from Merid.	80	00—	9.239670
To t. Altit. in Equinoctial	7	51—	9.139756

And after the same manner is the fifth Column of the following Table calculated under ♈ and ♎, which must be finished before the other can be done.

Then if the Sun have Declination, the Meridian Altitudes are given in the foregoing Table; but when he is not on the Meridian, but on some other Azimuth, then say,

As the Sine of the Latitude,
To the Sine of the Declination;
So is the Co. Sine of the Altitude at the Equinoctial,
To the Sine of the fourth Arch.

Now observe these Rules:

1. If the Latitude and Declination be both of one Denomination, that is, both North, or both South, on all Azimuths from the Prime Vertical unto the Meridian, or less than 90 Degrees, then add the fourth Arch found by the Proportion above, to the Altitude at the Equinoctial; that Sum is the Sun's Altitude on the given Azimuth.

2. If the Latitude and Declination are both alike, and the Azimuth more than 90 Degrees distant from the South, take the Altitude at the Equinoctial out of the fourth Arch, the Remainder is the Altitude of the Sun on the given Azimuth.

3. When

3. When the Latitude and Declination are unlike, or of different Names, then take the fourth Arch out of the Sun's Altitude at the Equinoctial, and the Remainder will give you the Sun's Altitude on the given Azimuth.

Example. What's the Sun's Altitude on the 80th Azimuth from the South, Declination 23 Degrees 29 Minutes North, and Latitude of the Place 51 Degrees 32 Minutes North? The Altitude in the Equinoctial was found before to be 7 Degrees 51 Minutes.

OPERATION.

As the Sine of the Latitude	51	32 Co. Ar.	0.106255
To S. Decl. North	23	29	9.600409
So C. ſ. Altit. in Equinoctial	7	51	9.995911
To S. fourth Ark	30	17	9.702575

Now according to the firſt Rule, becauſe the Latitude and Declination are both North, I add the fourth Arch 30 Degrees 17 Minutes to the Sun's Altitude in the Equinoctial 7 Degrees 51 Minutes, and the Sum 38 Degrees 8 Minutes is the Sun's Altitude upon the given Azimuth, as was required.

And to make all yet plainer, I ſhall add more Examples in the Tropics, and ſhew how one Analogy ſerves for both Tropics.

Firſt, for Altitude Sun on the Meridian.

	Deg.	Min.	
Height Equinoctial at *London*	38	28	
Declination add and ſubtract	23	29	
	Z 61	57	M. Alt. ♋
	X 14	59	M. Alt. ♑

2. *For Sun's Altitude on 10th Azimuth in the Tropics.*

	Deg.	Min.	
As S. Latitude	51	32 Co. Ar.	0.106255
To S. Decl.	23	29	9.600409
So C. ſ. Alt. Equinoct.	38	2	9.896335
To S. of the Arch	23	38	9.602999
Z is the Altit. in ♋	61	40	
X is the Altit. in ♑	14	24	

3. For

3. *For the Sun's Altitude on the 20th Azimuth from the South.*

	Deg.	Min.		
As S. Latitude	51	32	Co. Ar.	0.106255
To S. Declination	23	29		9.600409
So C.f. in the Equator	36	44		9.903864
To S. of the Arch	24	4		9.610528
Z is Alt. in ♋	60	48		
X is Alt. in ♑	12	40		

4. *For Altitude Sun on the 30th Azimuth.*

	Min.	Sec.		
As S. Latitude	51	32	Co. Ar.	0.106255
To S. Declination	23	29		9.600409
So C. f. Altit. in Equinoct.	34	32		9.915820
To S. of the Arch	24	47		9.622484
Z is Alt. in ♋	59	19		
X is Alt. in ♑	9	45		

And after this manner is the Sun's Altitude obtained in the Tropic, when the Azimuth is less than 90 from the South; but when it is more, *viz.* 100 110, 120 Degrees from the South, then observe, that the Sun in the Equinoctial has the same Depression under the Horizon on the 100th Azimuth, that he has Altitude on the 80th Azimuth; therefore subtract the Altitude in the Equinoctial from the fourth Arch, gives the Altitude on the given Azimuth.

5. *Example.* What's the Sun's Altitude in the Tropic of *Cancer* on the 100th Azimuth from the South, Latitude as before?

OPERATION.

	Deg.	Min.
The fourth Arch for the 80th Azimuth is	30	17
Sun's Altit. in Equinoct. on 80th Azimuth sub.	7	51
Sun's Altit. in ♋ on 100th Azimuth	22	26

6. *For*

6. *For Sun's Altitude in* ♋ *on the* 110*th Azimuth from the South.*

	Deg.	Min.
The fourth Arch for 70th Azimuth is	29	25
Sun's Altitude in Equator on 70th Azimuth sub.	15	11
Sun's Altitude in ♋ on 110th Azimuth	14	14

7. *For Sun's Altitude in* ♋ *on the* 120 *Azimuth from the South.*

	Deg.	Min.
The fourth Arch for the 60th Azimuth is	28	14
Sun's Altitude in Equinoctial on the 60th Azimuth	21	38
Sun's Altitude in ♋ on the 120th Azimuth	6	36

8. *To find the Sun's Altitude in the beginning of* ♊ ♌ *on the* 120*th Azimuth from the South.*

You must first find the fourth Arch to the 60th Azimuth thus:

	Deg.	Min.		
As S. Latitude	51	32	Co. Ar.	0.106255
To S. Declination	20	11	15—	9.537937
So C. f. Alt. Equi. on 60th Azim.	21	39	0—	9.968228
To S. of the Arch	24	11		9.612420
Sun's Altit. in ♊ ♌ on 120th Azi.	2	32		

9. *To find the Sun's Altitude in the beginning of* ♉ ♍ *on the* 80*th and* 100*th Azimuth from South.*

	Deg.	Min.		
As S. Latitude	51	32	Co. Ar.	0.106255
To S. Declination	11	29	33	9.299376
So C. f. Altitude in Equinoctial	7	51	00	9.995911
To S. of the Arch	14	36	00	9.401542
Z is Altitude on 80th Azimuth	22	27		
X is Altitude on 100th Azimuth	6	45		

10. *To find Sun's Altitude in the beginning of ♏ ♓ on the 70th Azimuth from the South.*

	Deg.	*Min.*	*Sec.*	
As S. Latitude	51	32	00	Co. Ar. 0.106255
To S. Declination	11	29	33	9.299376
So C. ſ. Alt. in Equinoct.	15	11	0	9.984569
To S. of the Arch	14	13	0	9.390200
X is Alt. in ♓ ♏ on 70 Azi.	0	58		

11. *To find Sun's Altitude in the beginning of ♐ ♒ on the 50th Azimuth from the South.*

	Deg.	*Min.*	*Sec.*	
As S. Latitude	51	32	0	Co. Ar. 0.106255
To S. Declination	20	11	15	9.537937
To C. ſ. Alt. in Equinoct.	27	3	0	9.949687
To S. of the Arch	23	7	0	9.593879
X is the Altit. in ♐ ♒ on the 50th Azimuth	3	56	0	

12. *For the Sun's Altitude on the 90th Azimuth or Prime Vertical in* Cancer.

Given, the Latitude 51 Degrees 32 Minutes North, Sun's Declination 23 Degrees 29 Minutes North, and 90 Azimuth, to find Sun's Altitude.

In the Scheme Prob. 11.

In the Triangle A Z P, right Angled at Z, and becauſe the Co. Declination A P, and the Co. Altitude A Z fall upon Co. Sines in the Circular parts, it will hold.

	Deg.	*Min.*	
As C S. Z P =	38	28	9.893745
To Radius =	90	00	10.000000
So C. ſ. A P =	66	31	9.600409
To C. ſ. A Z =	59	24	9.706654

That

That is,

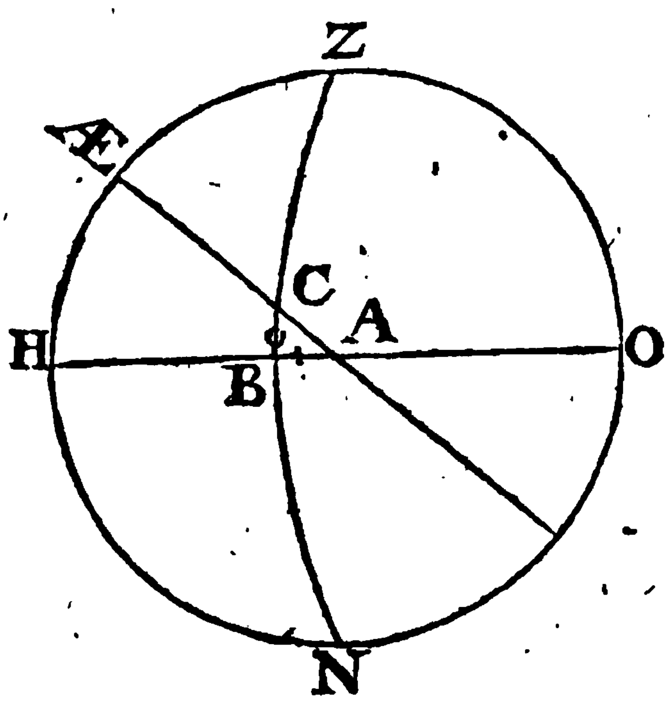
	Deg.	Min.	
As S. Latitude	51	32	9.893745
To Radius	90	0	10.000000
So S. Decli.	23	29	9.600409
To S. Alti.	30	36	9.706664

13. *For the Sun's Altitude on the 90th Azimuth in* ♊ ♌.

	Deg.	Min.	
As S. Latitude	51	32	9.893745
To Radius	90	00	10.000000
So S. Decli.	20	11	9.537851
To S. Alt.	26	9	9.644106

14. *For Alt. Sun on the 90th Azimuth in* ♉ ♍.

	Deg.	Min.	
As S. Latitude	51	32	9.893745
To Radius	90	00	10.000000
So S. Decli.	11	30	9.299655
To S. Alti.	14	45	9.405910



Lastly, For Altitude of the Sun on the 70th Azimuth in the Equinoctial. In the right angled spheric Triangle A B C, right Angled at B.

	Deg.	*Min.*	
As C t. B A C	38	28	10.099913
To Radius	90	00	10.000000
So S. B A	20	00	9.534052
To t. B C	15	12	9.434139

Or by Transposition say,

	Deg.	*Min.*	
As Radius	90	00	10.000000
To C t. Latitude	51	32	9.900086
So C f. Azimuth from South	70	00	9.534052
To t. of the Altitude B C	15	12	9.534138

And after this manner have I Calculated the following Table of the Sun's Altitude upon every tenth Azimuth in the beginning of every one of the twelve Signs; (by help of which and the following Table the Azimuth may be laid down on a Quadrant) which may be done to every Degree of Azimuth and to any particular Latitude at Pleasure; the Degrees answering 10 Deg. of Azimuth are the Meridian Altitude of the Sun, and the rest of the Table is found by Calculation, as I have shewed above.

A TABLE

A Table of the Altitude of the Sun in the beginning of each Sign, for every 10 Degrees of Azimuth, in the Latitude of 51 Degrees 32 Minutes North.

Azimuth from South	♋ °	♋ '	♊ ♌ °	♊ ♌ '	♉ ♍ °	♉ ♍ '	♈ ♎ °	♈ ♎ '	♓ ♏ °	♓ ♏ '	♒ ♐ °	♒ ♐ '	♑ °	♑ '
0	61	57	58	39	49	58	38	28	26	58	18	17	14	59
10	61	40	58	22	49	36	38	2	26	28	17	43	14	24
20	60	49	57	26	48	11	36	44	25	7	16	3	12	40
30	59	19	55	50	46	38	34	32	22	25	13	14	9	45
40	57	16	53	27	43	53	31	19	18	46	9	15	5	33
50	54	[illegible]	50	10	40	9	27	3	13	56	3	56	0	5
60	49	54	45	51	35	21	21	39	7	58				
70	44	38	40	25	29	25	15	12	0	58				
80	38	9	33	44	22	27	7	51						
90	30	36	26	9	14	45	[illegible]	0						
100	22	20	18	0	6	49								
110	16	14	9	56										
	6	36	2	32										

After this manner did I calculate all the Requisites for Delineating the Hours and Azimuths upon a Quadrant for *Madrid* in *Spain*.

By *Prob.* 18, the following Table of the Sun's Azimuth is Calculated.

A Ta-

A TABLE of the Sun's Azimuth from the South at his Entrance into the 12 Signs, and at each Hour and Quarter of the Day, for the Latitude of 51 Degrees 32 Minutes North.

Hours.		♋ °	'	♊ ♌ °	'	♉ ♍ °	'	♈ ♎ °	'	♓ ♏ °	'	♒ ♐ °	'	♑ °	'
12		0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7	10	5	50	5	35	4	53	3	52	3	50	3	50
		14	22	13	22	11	8	9	38	7	55	7	38	7	8
		21	27	19	50	16	40	14	10	12	8	11	8	10	35
11	1	27	54	25	58	22	11	18	50	16	20	14	41	14	10
		34	14	32	0	27	30	23	20	20	12	18	15	17	36
		40	12	37	38	32	39	27	40	24	2	21	50	20	57
		45	39	43	0	37	30	32	6	29	40	26	28	24	23
10	2	50	41	47	55	42	0	36	21	31	48	28	50	27	46
		55	31	52	41	47	0	40	28	35	12	32	16	31	0
		60	8	57	9	50	50	44	24	39	8	35	37	34	15
		64	9	61	16	54	30	48	10	42	32	38	48	37	34
9	3	68	8	65	14	58	45	51	54	46	0	42	0	40	40
		71	50	69	54	62	30	55	30	49	23	45	14	43	43
		75	24	72	35	66	8	58	57	52	40	48	17	46	44
		78	46	76	2	69	36	62	20	55	51	52	0	50	10
8	4	81	52	79	18	72	55	65	38	58	57	54	24		
		85	6	82	40	76	10	68	50	62	5				
		88	8	85	36	79	20	72	2	65	12				
		91	7	87	48	82	26	75	0	68	10				
7	5	93	58	91	30	85	28	78	4	71	8				
		96	49	94	23	88	25	81	7						
		99	38	97	14	91	23	84	2						
		102	33	100	5	94	20	87	0						
6	6	105	6	102	52	97	10	90	0						
		107	50	104	56	100	0								
		110	34	108	24	103	0								
		113	16	111	12	105	52								
5	7	116	0	114	0										
		118	50	116	52										
		121	40	119	45										
		124	18	122	36										
4	8	127	22												
		129	50												

Note, the 129° 50' is the Sun's Azimuth at the time of the rising and setting of the Sun in the Tropic of *Cancer*, and 50° 10' is the Azimuth when he rises and sets in the Tropic of *Capricorn*.

PROB.

PROB. XXVII.

Given, the Sun's Place, and Time of the Day or Night (under any known Meridian) to find the Right Aſcenſion of the Mid-Heaven.

To the Time propoſed, find the Sun's Right Aſcenſion by Prob. 3. then reduce the apparent Time of the Day or Night into Degrees and Minutes, and add it to the Sun's Right Aſcenſion before found; that Sum is the Right Aſcenſion of the *Medium Cœli*, or Mid-heaven. If the Sum exceed 360°, reject 360° and the Remainder is the Right Aſcenſion of the Mid-Heaven.

Example. *Anno* 1728, *March* 13, at 22 *min.* paſt 8 in the Morning the Sun's Place is ♈ 3° 55′ 47″, and his Right Aſcenſion 3° 36′ 6″; I demand the Right Aſcenſion of the Mid-heaven at *London*.

OPERATION.

		Deg.	Min.	Sec.	
Apparent Time in the Meridian of *London*.	Hours 20 =	300	00	00	By the Table in the 2d Vol. for this Purpoſe.
	Min. 22 =	5	30	00	
Sun's Right Aſcenſion add		3	26	06	
Sum, is R. A. *Medium Cœli*		308	56	6	
		360	00	00	
Complement ſhort of ♈		51	03	54	

Note, When the Sum is leſs than 90 *degr.* it is the Right Aſcenſion from ♈; if it be more than 90 *deg.* and leſs than 180 *deg.* ſub. from 180; if more than 180 *deg.* and leſs than 270 *deg.* ſub. 180 *deg.* from it: But if it fall in the laſt Quadrant, as in the Example above, ſubtract it from 360, and you have the Quantity of Degrees and Minutes that you are to make uſe of in Trigonometrical Calculations.

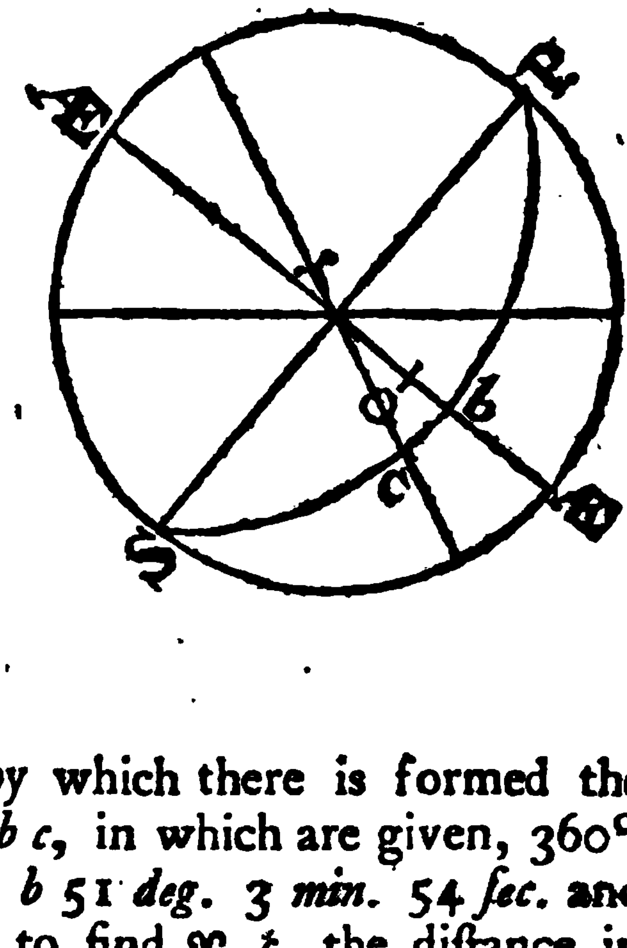
This

This Problem is of singular use in the Calculations of Solar Eclipses, as I shall shew in the Precepts for that Purpose.

PROB. XXVIII.

Given, the Obliquity of the Ecliptic 23 Degrees 29 Minutes, and the Right Ascension of the Mid-heaven, to find the Culminating Point, or Medium Cœli *in the Ecliptic.*

Example. Let the Right Ascension of the *Medium Cœli* be 308 *deg.* 26 *min.* 6 *sec.* what Point of the Ecliptic is then upon the Meridian?



Draw the Primitive Circle, which here represents the Solstitial Colure, by what has been taught in the Projection of the Sphere; draw the Equinoctial Æ Æ, and Ecliptic ♈ *c*; then because the given Right Ascension of the Mid-heaven is 308 *deg.* 56 *min.* 6 *sec.* that is 38 *deg.* 56 *min.* 6 *sec.* from the Solstitial Colure, take the Secant of 38 *deg.* 56 *min.* 6 *sec.* and draw the Meridian or Hour-circle P *b* S by which there is formed the Right-angled spheric Triangle ♈ *b c*, in which are given, 360° — 308 *deg.* 56 *min.* 6 *sec.* = ♈ *b* 51 *deg.* 3 *min.* 54 *sec.* and the Angle *c* ♈ *b* 23 *deg.* 29 *min.* to find ♈ *t*, the distance in the Ecliptic from ♈ to the Meridian.

ANALOGY.

	Deg.	Min.	Sec.	
As t. ♈ *b* the R. A. *M. Cœli*	51	3	54	10.092639
To Radius	90	0	00	10.000000
So C. f *Angle c* ♈ *b* Obliquity	23	29	00	9.962453
To C. t. ♈ *c*	53	27	42	9.869814

Or

Or, by Transposition.

		Deg.	Min.	Sec.	
As Radius		90	00	00	—10.000000
To C. s. Obliquity		23	29	00	— 9.962453
To C. t. R. A. *M. C.*		51	3	54	— 9.907362
To C. t. of its Dist. from ♈		53	27	42	— 9.869815
This 53 *deg.* 27 *min.* 42 *sec.* is =	1	23	27	42	
From ♈ or	12	00	00	00	
Rem. Culminating Point	10	6	32	18	

Note, That the distance found by Trigonometry is always from the same Equinoctial Point ♈, or ♎, that the Right Ascension of the Mid-heaven was taken from.

PROB. XXIX.

Given, the Obliquity of the Ecliptic, and the Right Ascension of the Mid-heaven, to find the Meridian Angle.

Example. In the Scheme of the last Problem, there are Given ♈ *b*, the Right Ascension Mid-heaven 51 *deg.* 3 *min.* 54 *sec.* and the Angle *c* ♈ *b* 23 *deg.* 29 *mn.* to find the Angle ♈ *c b.*

ANALOGY.

As Radius	90	00	00	— 10.000000
So s. Obliquity	23	29	00	— 9.600409
So. C. s. R. A. *Med. Cœli*	51	3	54	—9.798263
To C. s. Meridian Angle	75	29	51	—9.398672

PROB. XXX.

Given, the Obliquity of the Ecliptic 23 Deg. 29 Min, and Right Aſcenſion of the Mid-heaven, to find the Declination of the Culminating Point.

Example. Let the Right Aſcenſion of the Mid-heaven be 308 *deg.* 56 *min.* 6 *ſec.* What's the Declination of the Culminating Point?

In the Triangle ♈ *b c* of the laſt Scheme, are given ♈ *b* 51 *deg.* 2 *min.* 54 *ſec.* Complement of 308 *deg.* 56 *min.* 6 *ſec.* and the Angle *c* ♈ *b*, the Obliquity of the Ecliptic, to find *c b* the Declination.

ANALOGY.

	Deg.	*Min.*	*Sec.*	
As Radius	90	00	00	—10.000000
To t. Obliquity	23	29	00	— 9.637956
So S. R. A. M. Heaven	51	3	54	— 9.890901
To t. Decl. Cul. Point South	18	40	22	— 9.528857

Note, When the Right Aſcenſion of the Mid-heaven is more than 180 *deg.* as in the Example above, than the Declination of the Culminating Point is South; for then the Culminating Point itſelf is in a ſouthern Sign: But if the Right Aſcenſion be leſs than 180 *deg.* the Longitude of the Culminating Point is in a northern Sign, and Declination North.

PROB. XXXI.

Given, the Latitude of the Place, and the Declination of the Culminating Point, to find the Altitude of the Mid-heaven.

Obſerve in north Latitudes,

If the Declination of the Culminating Point be North, add it to the Complement of the Latitude, or Elevation of the

the Equinoctial above the Horizon; the Sum is the Altitude of the Mid-heaven.

But if the Declination be South, ſubtract it from the Complement of the Latitude, and the Remainder is the Altitude of the Mid-heaven.

In ſouth Latitude, you muſt ſubtract the north Declination, and add the South to the Complement of the Latitude of the Place; the Sum or Difference, is the Altitude of Mid-heaven.

Example At *London*,	*Deg.*	*Min.*	*Sec.*
The Elevation of the Equinoctial is	38	28	00
Declin. Culminating Point South is	18	40	22
Remains Altitude Mid-heaven	19	47	38

Example 2. At *London*, let the Delination of the Culminating Point be 15 *deg.* 17 *min.* 46 *ſec.* North; What's the Altitude of the Mid-heaven?

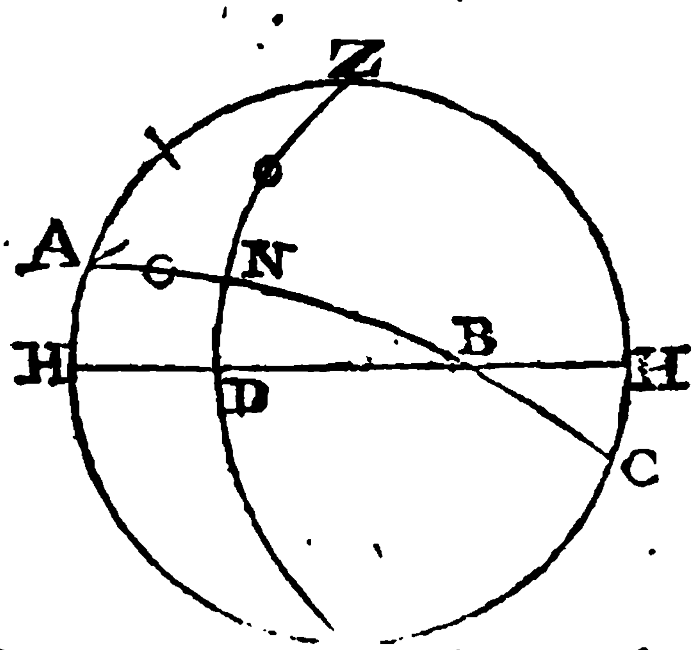
OPERATION.

	Deg.	*Min.*	*Sec.*
Height of the Equinoctial	38	28	00
Decl. Culmin. Point North add	15	17	46
Altitude of the Mid-heaven	53	45	46

PROB. XXXII.

Given, the Altitude of the Mid-Heaven, and the Meridian Angle, to find the Altitude of the Nonageſime Degree, or the Angle that the Ecliptic makes with the Horizon at any given Time.

Example. Anno 1728, *March* 13, at 22′ paſt 8 in the Morning, I demand the Altitude of the Nonageſime Degree at *London*?



With any convenient Radius, and the Chord of 60 Degrees sweep the Primitive Circle, which here represents the Meridian of *London*; draw H H for the Horizon; then by the foregoing Problem I find the Altitude of the Mid-Heaven 19 *degr.* 47 *min.* 38 *sec.* and the Meridian Angle 75 *deg.* 29 *min.* 51 *sec.* Take the Chord of 19 *deg.* 47 *min.* 38 *sec.* and set it from H to *A*, which is the Altitude of the Mid-Heaven. Then because the Meridian-angle is 75 *deg.* 29 *min.* 51 *sec.* take the Secant thereof, and sweep the Ecliptic ABC; then by having the Side AZ, the Complement of the Altitude of the Mid-heaven, 70 *deg*, 12 *min.* 22 *sec.* and the Angle Z A N, the Meridian Angle, I find the Angle A Z N to be 37 *deg.* 21 *min.* take the Secant of 37 *deg.* 21 *min.* and draw the Vertical Circle Z N D, and it will cut the Ecliptic at N in the Nonagesime Degree at right Angles. Now in the Right-angled Spheric Triangle AZN (Right-angled at N) there are Given A Z, the Complement of the Altitude of the Mid-heaven 70 *deg.* 12 *min.* 22 *sec.* and the Angle NAZ, the Meridian Angle 75 *deg.* 29 *min.* 51 *sec.* to find N Z, the Complement of the Nonagesime Degree.

ANALOGY.

	Deg.	*Min.*	*Sec.*	
As Radius	90	00	00	10.000000
To S. Meridian-angle	75	29	51	9.985937
So C. f. Altit. Mid-heaven	19	47	38	9.973552
To C. f. Alt. Nonagesime	24	21	53	9.959489

PROB. XXXIII.

Given, the Meridian-angle, and the Altitude of the Mid-heaven, to find the Nonagesime Degree.

In the last Scheme, there are the same things given, to find the Side A N, the Distance of the Mid-heaven from the Place of the Nonagesime Degree.

ANA-

ANALOGY.

	Deg.	Min.	Sec.	
As Radius	90	00	00	10.000000
To C, t. Alt. Mid-heaven	19	47	38	10.443817
So C. f. Meridian angle	75	29	51	9.398651
To t. dist. Mid-heaven from Nonag.	34	49	45	9.842468

Now you are to observe, that if the Place of the Mid-heaven (as found by *Prob.* 28)

be in { ♑ ♒ ♓ ♈ ♉ ♊ add / ♋ ♌ ♍ ♎ ♏ ♐ sub. } the Distance of the Mid-heaven from the Nonagesime Degree to, or from the Place of the Mid heaven, the Sum or Difference is the Place of the Nonagesime Degree. But if the Habitation of your Abode be South, then you must add where you now subtract, *et vice versa.*

So in the Example before us, the Place of the Mid-heaven is in ♒, that is,

	S.	°	′	″
ven is in ♒, that is,	10	6	32	18
Dist. Mid-heaven add	1	4	49	45
Place of the Nonagesime Degree	11	11	22	3

These seven last Problems, are of great use in the Calculation of solar Eclipses

PROB XXXIV.

Given, the Latitude of the Place, and the Time of the Day or Night, to find the Cusp of the Ascendent.

Example. Anno 1727, *September* 14 at 15 Min. past 5 at Night equal Time, I would know the Degrees and Minutes of the Ecliptic that is ascending the eastern Horizon at *London.*

OPERATION.

	Deg.	Min.	Sec.
Sun's Place	♎ 2	1	51
Sun's Right Ascension	181	52	0
Time from Noon in Degrees and Minutes	78	45	0
Right Ascension Mid-heaven	260	37	0
Add	90	00	00
Sum is oblique Asc. Ascendent	350	37	0
Complement next to ♈	9	23	0

Now

Now say,

	Deg.	Min.	
As Radius	90	0—	10.000000
To C. s. Oblique Asc. Ascendent	9	23—	9.994150
So C. t. Latitude of the Place	51	32—	9.900086
To C. t. of the Arch	51	55—	9.894236

Now Note, When the Oblique Ascension of the Ascendent is nearer ♈ than ♎, (as in this Example) then you must add the Obliquity of the Ecliptic $23^{\circ}\ 29'$, to the first Arch, the Sum is the second; but if it be nearer ♎ than ♈, then subtract the Obliquity $23^{\circ}\ 29'$ from the first Arch, gives the Second.

	Deg.	Min.
The first Arch is	51	55
Obliquity Ecliptic add	23	29
The second Arch	75	24

Now say,

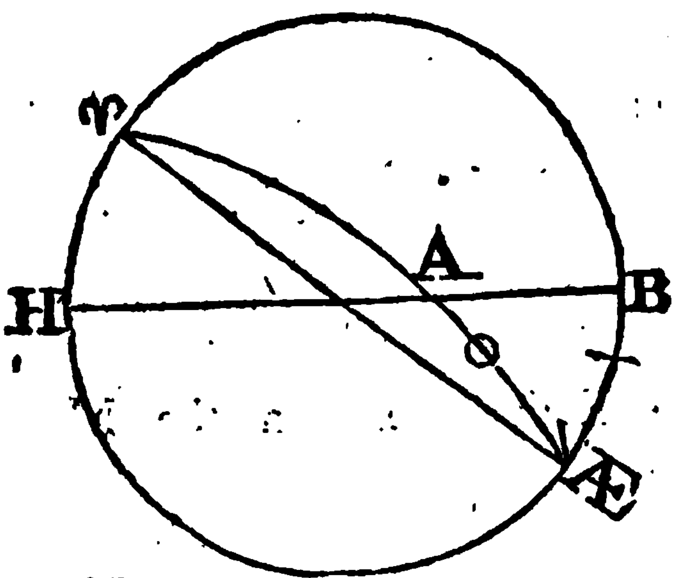
		Deg.	Min.	
As C. s. Second Arch		75	24	Co. Ar. 0.598479
To C. s. first		51	55	9.790149
So t. Oblique Asc. Ascend.		9	23	9.218142
To. t. of its Dist. from ♈ S.		22	1	9.606776
From	12	00	00	
Cusp. Ascendent	11	7	59	

Further Note, that if the Second Angle be less than 90°, the Distance in the Ecliptic found by the second Operation above must be accounted from the same Equinoctial Point that the Oblique Ascension was reckoned from.

But if the second Angle be more than 90°, then the Distance in the Ecliptic must be accounted from the contrary Equinoctial Point that the Oblique Ascension was reckoned from.

If the Cusp of the Ascendant (or the Arch contained between the Meridian and Horizon) were required when either no *deg.* of ♈ or ♎ is on the Meridian, then the young Student will be at a loss; because the foregoing Anology will not hold; the Oblique Ascension of the Ascendent will be

be 90 when no *degr.* of ♈ Culminates, and 270° when ♎ is there, that is, in both Cases equally distant from ♈ and ♎; so that the Obliquity of the Ecliptic cannot be apply'd as has been directed. Then to remedy this defect, there must be a new Rect-angled Spheric Triangle formed (and when no Degrees of ♈ is on the Meridian) under the northern Horizon: Thus



draw the primitive Circle to represent the Meridian of *London*; and because the Meridian Angle is 66 *degr.* 31 *min.* when ♈ and ♎ Culminates, take the Secant of 66 *degr.* 31 *min.* and draw ♈ A Æ for one half of the Ecliptic, and ♈ Æ, a right Circle for the Equinoctial, to the Elevation of *London*, HB the Horizon; then in the Right-angled Spheric Triangle ÆAB there are given, Æ B the Complement of the Latitude 38 *deg.* 28 *min.* and the Angle B Æ A, the Meridian Angle 66 *degr:* 31 *min.* to find A Æ, the Arch of the Ecliptic between the Horizon and north Meridian from *Libra*.

ANALOGY.

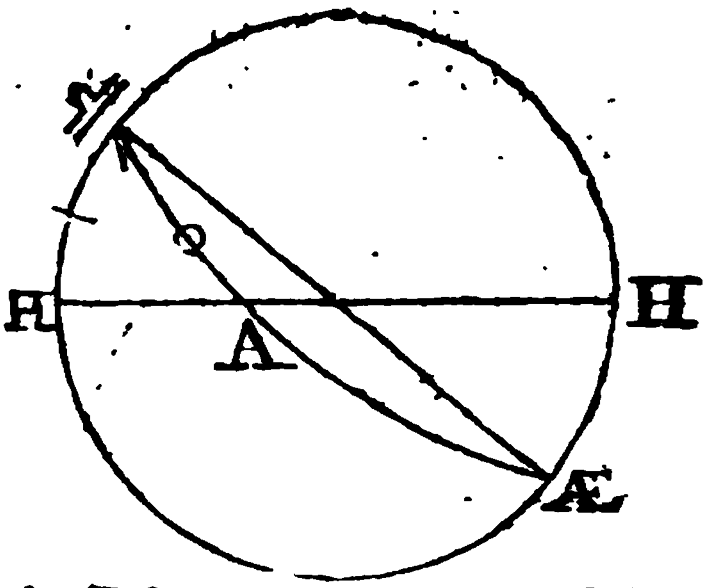
	Deg.	*Min.*	
As t. B Æ	38	28—	9.900086
To Radius	90	00—	10.000000
So C. f. *Angle* B Æ A	66	31—	9.600409
To C. t. A Æ	63	22—	9.700323
A Semicircle	180	00—	
Remains Æ A	116	38—	

That is the Arch of the Ecliptic from ♈ on the South Meridian to A above the Horizon; that is, ♋ 26° 38′ for the Cusp of the Ascendent in the Latitude of 51° 38′ North, when no Degrees of ♈ Culminate.

Example 2. Let it be required to find the Cusp of the Ascendent at *London* when no Degrees of *Libra* Culminate.

The

This is projected as the last was, by taking the Secant of the Meridian - angle 66 *deg.* 31 *min.* and drawing ♈ A Æ for half the Ecliptic, HH the Horizon, and H ♎ H Æ the Meredian; then in the Rect-angled Spheric Triangle A H ♎, the Altitude of the *Medium Cœli*, equal to the Height of the Equinoctial 38° 28′, and the Meridian angle H ♎ A 66° 31′, to find ♎ A the Arch of the Ecliptic between the Meridian and Horizon.



Analogy by Transposition.

	Deg.	Min.	
As Radius	90	00	—10.000000
To t. Latitude	51	32	—10.099913
So C. ſ. Meridian Angle	66	31	— 9.600409
To C. t. of ♎ A	63	22	— 9.700322

which is equal to A Æ in the last Scheme. Then 63° 22′ = 2 S. 3° 22′ + 6 S. = 8 S. 3° 22′ the Cusp of the Ascendent, when no Degrees of ♎ Culminate. *Note*, Where no Degrees of ♋ or ♑ Culminate, three of the five Parts in the Triangle are Quadrants, and consequently the Arch of the Ecliptic between the Meridian and Horizon is known to be a Quadrant. And after the same manner have I calculated this Table, shewing the Cusp of the Ascendent when no Degrees of every Sign Culminate at *London*.

Mid-

Mid-heaven.	Cusp of the Ascendent. °	′	Arch Ecliptic between Meridian and Horizon.		The same Arch in Time. h.	′	″
♈	♋ 26	38	116	38	7	46	32
♉	♌ 16	30	106	30	7	6	0
♊	⊙ 7	21	97	21	6	29	24
♋	♎ 00	00	90	00	6	00	0
♌	♍ 22	38	82	38	5	30	32
♍	♏ 13	30	73	30	5	54	0
♎	♐ 3	22	63	22	4	13	28
♏	♐ 25	15	55	15	3	41	00
♐	♑ 27	10	57	10	3	48	40
♑	♈ 00	00	90	00	6	0	0
♒	♊ 2	50	122	50	8	11	20
♓	♋ 4	45	124	45	8	19	0

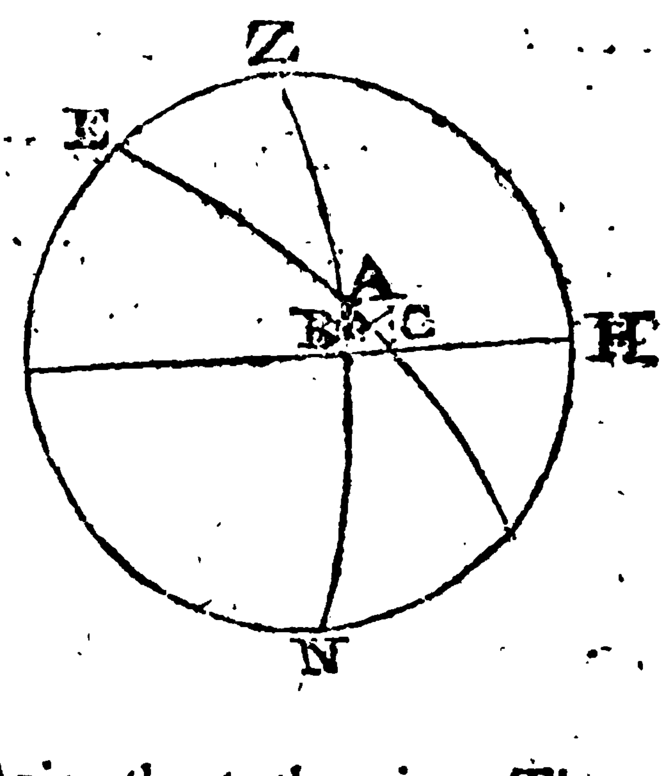
PROB. XXXV.

Given, the Latitude of the Place, the Hour of the Day, the Sun's Altitude and Distance from the Ascendent, or Descendent, to find the Parallactic Angle.

Example. At *London Anno* 1733, *May* 2 d. 6 h. 35′ 39″ (by a former Investigation of mine) is the apparent Time of the visible Conjunction of the Sun and Moon at which Time I demand the Parallactic Angle?

OPERATION.

		Deg.	Min.	Sec.
Sun's Place to the equal Time	♉	22	52	57
Sun's Declination North		18	21	00
Altitude of the Sun		8	58	00
Right Ascension		50	28	00
Apparent Time from Noon		98	54	45
Sum, R. A. *M. Cæli*		149	22	45
Add		90	00	00
Oblique Asc. Ascendent		239	22	45
Complement		59	22	45
Cusp of the Ascendent	♏	11	37	00
Cusp of the Descendent	♉	11	37	00
Sun's Place	♉	22	52	57
Dist. ☉ from Descendent		11	15	57
Medium Cæli in Ecliptic	♌	27	10	00
Declination Culminating Point North		12	36	00
Altitude Mid-heaven		51	4	00
Meridian-angle		69	47	00
Amplitude North		30	42	00
Sun's Azimuth from the North		71	24	00



To project this Problem; with the Chord of 60 Deg. draw the Primitive Circle to represent the Meridian of the Place, H H the Horizon, take the Altitude of the Mid-heaven 51 Deg. 4 Min. from the Line of Chords, and set it from H to E, and the Amplitude by the Semi-tangents from the Center to C; take the Secant of the Meridian-angle 69 Deg. 57 Min. and draw E A C for the Ecliptic: Then because the Sun's Azimuth at the given Time is 71 Deg. 24 Min. from the North, take the Secant of 71 Deg. 24 Min. and draw Z A N, which cuts the Ecliptic in *A* the Place of the Sun: And now by these three great Circles, *viz.* the

the Horizon, Ecliptic, and Azimuth, we have the Rect-angled Spheric Triangle *A B C*, Right-angled at *B*, in which are given *B A*, the Sun's Altitude 8 Deg. 58 Min. and *A C* the Sun's Distance from the Descendent 11 Deg. 15 Min. 57 Sec. to find the Angle *B A C*, the Angle formed by the Vertical Circle and Ecliptic.

ANALOGY.

	Deg.	Min.	
As Radius	90	00	10.000000
To t, B A ☉ Altitude	8	58	9.198674
So C. t. A C, ☉ à Descendent	11	16	10.700678
To C. t. *Angle* B A C Parallactic Angle	37	31	9.899352

PROB. XXXVI.

Given, the Sun's Altitude and Distance from the Nonagesime Degree, to find the Parallactic Angle.

Example. *Anno* 1733, *May* 2 d. 6 h. 35′ 39″ at *London*, I would know the Parallactic Angle?

OPERATION.

	S.	°	′
Cusp of the Descendent	1	11	37
Add	3	00	00
Nonagesime Degree	4	11	37
Sun's Place sub.	1	22	53
Distance	2	18	44
Altitude *Med. Cœli*		50	58
Altitude Nonag. Deg.		53	44
Meridian-angle		69	56

PROJECTION

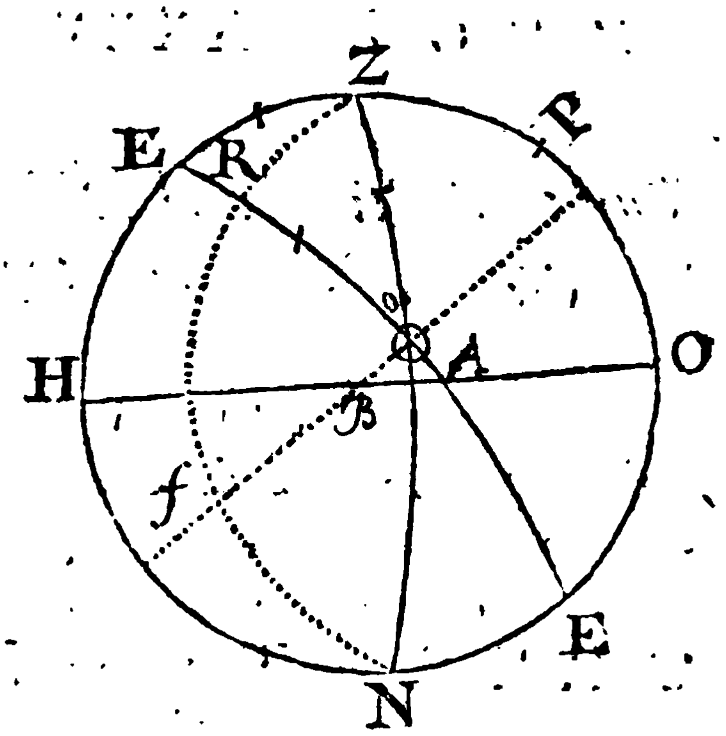
I. Draw the Primitive Circle, representing the Meridian of the Place.

II. Draw H O for the Horizon.

III. Take the Chord of the Altitude of the Mid-heaven 50 58' and set from H to E, a Ruler laid from E to B, given E the opposite Point.

IV. with the Secant of 69° 56' the Meridian-angle, draw E R A E for the Ecliptic, whose Pole is at *f*.

V. Through the three given Points Z *f* N, draw the Oblique Circle Z R *f* N, and it will cut the Ecliptic in R. the Nonagesime Degree. So is R. ⊙ the Sun's Distance from the Nonagesime Degree = 78° 44' which lay from R to ⊙, and draw Z ⊙ N. ⊙ Z the Complement of the Sun's Altitude, to find the Angle R. ⊙ Z, the parallactic Angle.



ANALOGY.

	Deg.	Min.	
As Radius	90	00	10.000000
To t. Sun's Altitude	8	58	9.198674
So t. Sun's Dist. à Nonag.	78	44	10.700678
To C. s. Parallactic Angle	37	31	9.899352

Or the same may be found in the Triangle A B ⊙

PROB.

PROB. XXXVII.

Given, the Sun's Parallax in Altitude, and the Parallactic Angle, to find his Parallax in Longitude and Latitude.

Note, The Sun's Parallax in Altitude you will find in a Table at the end of the Lunar Tables; in which the Parallax in Altitude answers to the Sun's Altitude, the greatest Horizontal Parallax being 10″.

First, For the Parallax in Longitude.

With the Sun's Altitude, take out of the Table the Parallax in Altitude 10″, and then say,

As Radius,
To t. Sun's Parallax in Alt.
So C. s. of Parallactic Angle,
To t. of Parallax in Longitude

2. For the Parallax in Latitude.

As Radius,
To S. Parallax in Altitude;
So S. Parallactic Angle,
To S. Parallax in Latitude.

The three last Problems have respect to the Ecliptic only; but in regard the Moon and other Planets and Stars are very seldom found there, therefore we must have respect to the Orb of the Planet, and find the Angle that a vertical Circle forms with it.

PROB. XXXVIII.

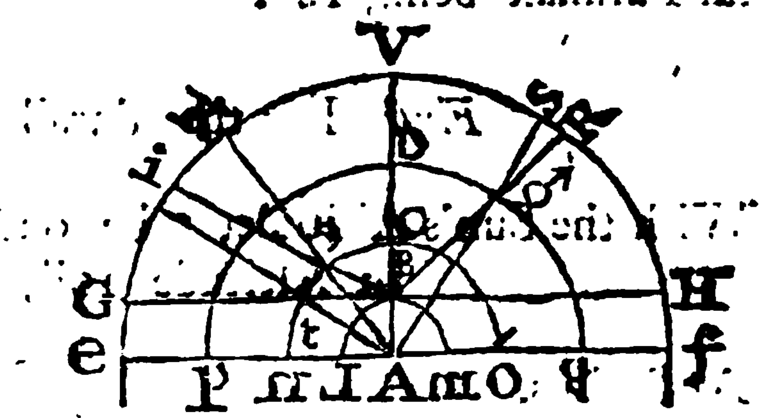
Of the Parallax of the Sun, Moon, and Stars.

In the *Definitions* I have told you what is meant by the Word *Parallax* in general: I shall in this Problem demonstrate the Parallaxes in Altitude, Longitude, Latitude and Horizontal

Horizontal: The use of them is so very great that the Knowledge thereof is the very Foundation of Astronomy.

Because from thence, the distance of the Sun, Moon, and Stars from the Earth may most easily be had; for in the Triangle A B *t*, A B the Earth's Semidiameter, B the Right-angle, and *t* the Angle of the Parallax being known, 'tis easy to find any Side or Angle sought, and consequently A *t*, the Distance of the Moon from Earth's Center.

In the adjacent Figure, let *A* represent the Earth's Center, *e f* the true Horizon, G H the visible, L B *m*, half the Earth's Superficies, *n c q* the Moon's Orb; an Observer at B, views the Moon at *i*; but an Eye from the Earth's Center at *A* would see her at K: So likewise if we put the Semi-circle P D *q* to represent the Orb of



Mars (or any other Planet) an Observer standing at B on the Earth's Superficies, will behold *Mars* at R; but from the Center it would be seen at S, and this Parallax vanishes in the Vertex or Zenith of your Habitation: For viewing a Star at V, both from the Earth's Center at *A*, and also from the Superficies at B, it will appear in one and the same Place of the Heavens; and the nearer the Horizon the Stars are, the greater is the Parallax of Altitude, and consequently the Horizontal is the greatest of all. Therefore, because the Places of all the Heavenly Bodies are supputated to the Earth's Center, (to which Place an Observer cannot come) and we being upon its Superficies, shews how needful the Knowledge of these Parallaxes are to him that would be an Astronomer: For as the Stars are raised by Refractions, so they are depressed by Parallaxes; and they depress the same way that the Planets appear; that is, if they appear to the Southward of the Zenith, the Parallax depresses them to the Southward; and so diminishes their Latitude if it be North; but increases it if it be South: And on the contrary, if the Planets appear to the North of the Zenith, the Parallax increases their North Latitude, and diminishes the South Latitude; all which will be very plain and easy, if you seriously consider the Diagram before you.

And

And further, is to be considered the Remoteness or Nearness of a Planet to the Earth: For *Saturn* being farthest from it, has the least Parallax of all; and the Moon being nearest to it, has the greatest; and so of the others, according to their Distance from the Earth; whose Horizontal Parallaxes at a middle Distance from the Earth I have stated thus:

	′	″	‴
♄	0	1	34
♃	0	2	49
♂	0	8	14
☉	0	10	0
♀	0	12	9
☿	0	13	59
☾	57	50	00

When a Circle of Longitude passing through the Poles of the Ecliptic, passes through the Nonagesime Degree, it then cuts the Ecliptic at right Angles; but in all other Places it cuts it at oblique Angles. Therefore, if a Planet appear neither in the Ecliptic, nor in the Nonagesime Degree, the Parallax in Altitude will cause a Parallax both in Longitude and Latitude.

Example. *Anno* 1727, *September* 15, at 8 at Night, at *London*, I would know the Parallax of the Moon in Altitude, Longitude, and Latitude?

First, For the Angle that the Vertical Circle forms with the Moon's Orb, proceed thus, *viz.* either find the Moon's distance from the Ascendent, or else from the Nonagesime Degree; either will do.

	Deg.	*Min.*	
Moon's true Longitude ♒	24	56	
Moon's true Latitude South	1	14	
Declination South	14	24	
Given Hour	8	0	
Moon South at	9	44	
Moon from Meridian	1	44	
Altitude	21	15	
Sun's Place	♎ 2	57	34″
Right Ascension	182	43	
Time from Noon Deg.	120	0	
Right A. M. *Cœli*	302	45	
Add	90	00	
Oblique A. Ascendent	392	43	

Complement

		Deg.	Min.
Complement		32	43
Cusp Ascendent ♊		3	29
Moon's Place sub. ♒ S.		24	56
Moon from the Ascendents	3	8	33
Complement	2	21	27
Angle formed by Vertical Circle and Moon's Orb		86	39

The Requisites above I have found by the foregoing Problems; and now for the given Time 8 at Night, find the Moon's Mean Anomaly 11 S. 07° 14′, 20″, and with that take out of the Table her Horizontal Parallax 55 Min. 12 Seconds; and then for her Parallax in Altitude, the Analogy is

	Deg.	Min.	Sec.	
As Radius,	90	00	00—	10.000000
To C. f. Moon's Altitude;	21	17	00—	9.969321
So S. Horizontal Parallax,	00	55	12—	8.205635
To S. Parallax in Altitude,	00	51	22—	8.174956
True Altit. of the Moon	21	17	00—	
Visible Altitude	20	25	38	

That the Sines of the Parallaxes of Altitude of the same Planet at different Distances from the Zenith, are directly as the Radius, to the Sine of the visible Distance of the Planet from the Zenith; or as the Co. Sines of their visible Altitudes above the Horizon.

2. *For the Parallax in Longitude.*

ANALOGY.

	Deg.	Min.	Sec.	
As Radius,	90	00	00—	10.000000
To t. Moon's Parallax in Altitude;	00	51	22—	8.174421
So C. f. *Angle* of her Orb and Vertical Circle,	86	39	00—	8.766675
To t. Parallax Longitude	00	3	00—	6.941096

Note

Note, If the Moon, &c. be between the Aſcendent and the Nonageſime Degree, the Parallax of Longitude muſt be added to her true Longitude; but if ſhe be between the Nonageſime Degree and Deſcendent, the Parallax of Longitude muſt be ſubtracted from the Moon's true Place in Longitude; the Sum or Difference is the Moon's Viſible Longitude.

EXAMPLE.

	S.	°	'	
Aſcendent	2	3	29	
Sub.	3	0	00	
Nonageſime Degrees	11	3	29	
Moon's true Place	10	24	56	to the Weſt.
Parallax Longitude ſubt.	00	3	00	
Moon's Viſible Longitude	10	21	56	

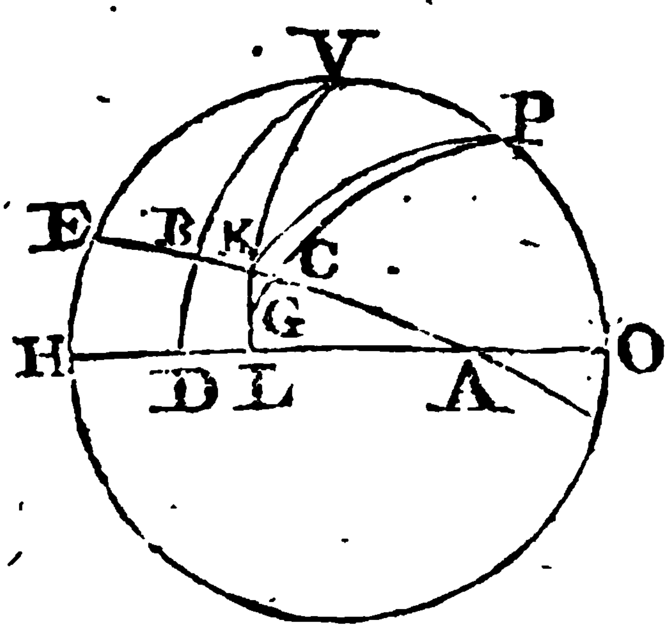
Note, If the Moon's Longitude be leſs than the Place of the Nonageſime Degree, ſhe is then in the Occidental Quadrant; but if more, in the Oriental.

3. For the Moon's Parallax in Latitude.

ANALOGY.

	Deg.	*Min.*	*Sec.*	
As Radius	90	00	00—	10.000000
To S. Parallax in Altitude;	00	51	22—	8.174956
So S. *Ang.* of her Orb and Vert. Cir.	86	39	00—	9.999257
To S. Parallax in Latitude,	00	51	16—	8.174213
True Latitude Moon South, add	1	14	00	
Viſible Latitude Moon South	2	5	16	

DEMONSTRATION.



Let H O, be the visible Horizon, whose Pole is V. E A an Arch of the Moon's Orb, whose Pole is P, V L, a Vertical Circle, passing thro' the Moon's true Place, in K, and the apparent Place in G; so will K G be the Parallax in Altitude: Thro' K and G, draw two Circles of Longitude as P K, and P G, cutting the Moon's Orb in K and C; then will K C be the Parallax in Longitude, and G C in Latitude V B D is a Vertical Circle passing through the Nonagesime Degree, B K the Moon's distance from the Nonagesime.

When the Sun, Moon or Planets are in the Nonagesime Degree, then there is no Parallax in Longitude, and then the Parallax in Latitude and Altitude are equal. And if they be in the Vertex, there is no Parallax of Latitude nor Altitude, but only in Longitude: If they be neither in the Vertex nor Nonagesime Degree, they have Parallax in Longitude, Latitude and Altitude, as has been above Calculated and Demonstrated.

PROB. XXXIX.

Given, the Horizontal Parallax of a Planet, the Altitude of the Nonagesime Degree, and its Distance from the Nonagesime Degree, to find the Parallax in Longitude and Latitude.

Rule. To the Logistical Logarithm of the Horizontal Parallaxes of the Planet, add the Sine of the Altitude of the Nonagesime Degree, and the Sine of the distance of the Planet from the Nonagesime Degree; the Sum of these three Logarithms is the Logistical Logarithm of the Parallax in Longitude.

Example. Anno 1727, *September* 15. at 8 o'Clock at Night at *London*, I would know the Parallax of the Moon in Longitude and Latitude?

You

You must first find these Requisites by the foregoing Problem, and set them down in Order thus:

		D.	H.	'	"
Given Time	1727 *Sept.*	15	8	00	00
Moon's Place	♒		24	56	00
Sun's Place	♎		3	7	34
Sun's Right Ascension			182	52	00
Time from Noon			120	00	00
Sum, Right Ascension *M. Cœli*			302	52	00
Complement			57	8	00
Medium Cœli in Ecliptic	♒		00	39	00
Meridian Angle			77	31	00
Declination Cul. Point South			20	3	00
Altitude Equator at *London*			38	28	00
Altitude Mid-heaven			18	25	00
Altitude Nonagesime Degree			22	8	00
Dist. Mid-heav. from Nonag. Degr.			32	59	00
Nonagesime Degree	♓		3	38	00
Moon's Place sub.	♒		24	56	00
Dist. Moon from Nonag. Degree			8	42	00
Mean Anomaly Moon		7	11	14	20
Horizontal Parallax Moon			90	55	12

Now, for the Parallax in Longitude of the Moon, the Work stands thus, by *Shakerley*'s Logistical Logarithms.

	Deg.	Min.	Sec.	
Horizontal Parallax Moon	00	55	12	LL 9.96379
Altitude of the Nonag. Degree	22	8	00	S. 9.57607
Dist. Moon from Nonag. Degree	8	42	00	S. 9.17973
Parallax in Longitude of Moon	00	3	9	LL 8.71959

2. For the Parallax in Latitude.

To *Shakerley*'s Logistical Logarithm of the Horizontal Parallax of the Planet, add the Co. Sine of the Altitude of the Nonagesime Degree; the Sum of these two Logarithms is the Logistical Logarithm of the Parallax in Latitude.

OPERATION.

	Deg.	Min.	Sec.	
Horizontal Parallax ☽	00	55	12	L L 9.96379
Altitude Nonagesime Degree	22	8	00	C S 9.96676
Parallax in Latitude ☽	00	51	7	L L 9.93055

See my *Uranoscopia*, Page 302.

And thus, have I given my Reader two ſeveral ways of finding the Parallaxes; and ſhall leave to his Choice to take which he likes beſt.

The greateſt Parallax of the Longitude may be found by adding the Logiſtical Logarithm of the Planets greateſt Horizontal Parallax, to the Sine of the Angle of its Orb with the Horizon (which is the ſame with the Altitude of the Nonageſime Degree in the Planet's Orb,) and the greateſt Diſtance of the Nonageſime Degree, which is 90°; the Sum of theſe three Logarithms is the Logiſtical Logarithm of the greateſt Parallax of Longitude of the Planet that can happen.

Example at *London* in the ☽, ſuppoſing her north Node to be in no Degrees of *Aries*, and ſhe upon the Meridian in no Degrees ♋; the Angle formed with the Horizon and Orb, will be 67° 14′ 20″.

OPERATION.

	Deg.	*Min.*	*Sec.*		
Greateſt Horizontal Parallax ☽	00	61	24	L L	10.01001
Altitude Nonageſime in her Orb	67	14	20	S.	9.26479
Her greateſt Diſt. from Non. Deg.	90	00	00	S.	10.00000
Her greateſt Parallax in Longitude		56	37	L L	9.97480

Alſo at *London* her greateſt Parallax in Latitude, may be found by the following Operation.

	Deg.	*Min.*	*Sec.*		
Greateſt Horizontal Parallax	0	61	24	L L	10.01001
Leaſt Altitude Nonageſime in her Orb	9	41	40	C S	9.99375
Greateſt Parallax of Longitude	1	00	31	L L	10.00376

And leaſt Parallax in Latitude may be found at *London* by the following Operation.

	Deg.	*Min.*	*Sec.*		
Leaſt Horizontal Parallax	00	54	59	L L	9.96208
Greateſt Altitude Nonag. in her Orb	67	14	20	C S	9.58759
Leaſt Parallax in Latitude	00	21	16	L L	9.54967

And thus by obſerving the Premiſes, you may find the greateſt Parallax in Longitude, the greateſt and leaſt Parallax in Latitude of a Planet, in any Latitude; which may be of good uſe to give you a right Idea of the Parallaxes; and will alſo ſhew you how they increaſe and decreaſe, and confirm your Calculation, by knowing between what two Numbers your Parallaxes at ſuch a Time and Place muſt fall.

The

The Parallax of the Moon in Longitude and Latitude, may be found by *Street*'s Logiſtical Logarithms.

R U L E.

Add the Logar. Sine of the Altitude of the Nonageſime Degree, to the Sine of the diſtance of the Moon from the Nonageſime Degree, this Sum, ſubtract from the Logiſtical Logarithm of the Moon's Horizontal Parallax. The Radius being firſt added, the Remainder will be the Logiſtical Logarithm of the Parallax of the Moon in Longitude.

See the Operation of the foregoing Example.

	Deg.	*Min.*	*Sec.*		
Horizontal Parallax Moon	00	55	12	L L	362
Altitude Nonageſime Degree	22	8	00	Sine	9.5761
Diſt. Moon from Nonag. Degr.	8	42	00	Sine	9.1797
Sum Subtract					8.7558
Parallax in Longitude of the Moon	00	3	9		~~1.8087~~ 1.2804

Note, Becauſe *Street*'s Logiſtical Logarithms go but to five Places, you muſt ever mind to take no more than five Places in counting the Index for one of the five in the Logarithm Sines, as you ſee here done.

For the Parallax of the Moon in Latitude by *Street*'s Logiſtical Logarithms.

R U L E.

From the Logiſtical Logarithm of the Moon's Horizontal Parallax, ſubtract the Logar. Co. Sine of the Altitude of the Nonageſime Degree, the Remainder is the Logiſtical Logarithm of the Parallax of the Moon in Latitude.

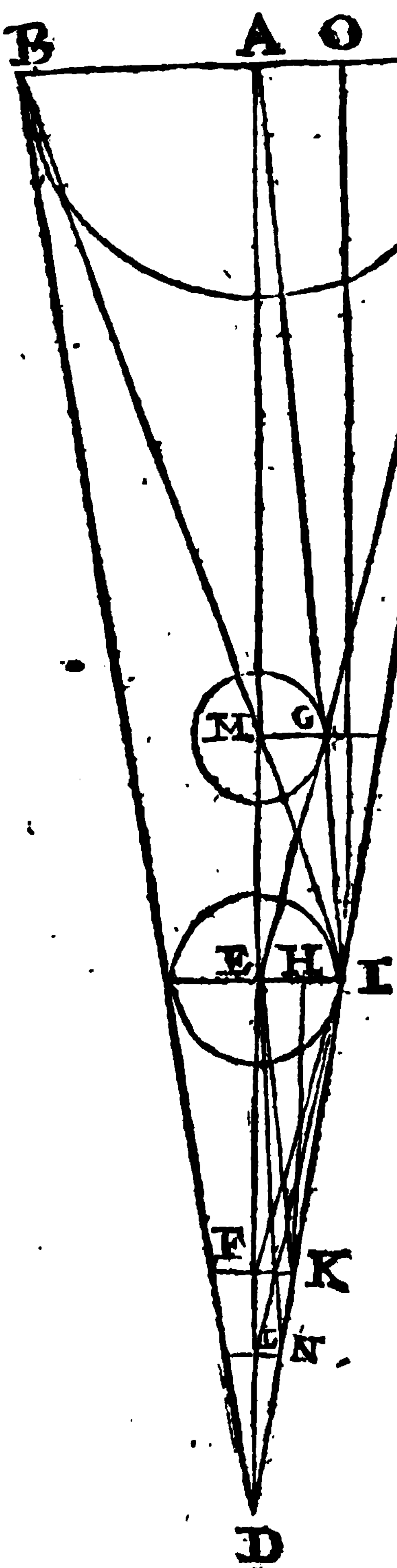
Operation to the Example before.

	Deg.	*Min.*	*Sec.*		
Horizontal Parallax Moon	00	55	12	L L	362
Altitude Nonageſime Degree	22	8		C. ſ.	99667
Parallax Latitude Moon		51	7		695

P R O B.

PROB. LX.

Shewing the several Methods made use of by Astronomers for obtaining the Horizontal Parallaxes of the Heavenly Bodies.



The first that I shall shew, is that famous Diagram of *Hipparchus*, and made use of by all Astronomers to this Day; exemplified in finding the Sun's Horizontal Parallax.

Let A be the Center of the Sun,

M that of the New Moon.

E the Center of the Earth.

F the Center of the full Moon in Perigeon.

L the Center of the full Moon in Apogeon.

Let all these Centers fall in the right Line A, M, E, F, L, D.

A B the Sun's true Semidiameter.

The *Angle* A E C, is the apparent Semidiameter Sun.

The *Angle* M E G is the apparent Semidiameter Moon.

The *Angle* F E K, the apparent Semidiameter of the Earth's Shadow when the Moon is in Perigeon.

The *Angle* L E N, the apparent Semediameter of the Earth's Shadow when the Moon is in Apogeon.

And the *Angle* E A I, is the Sun's Horizontal Parallax.

The

The *Angle* E M I, is the Moon's Horizontal Parallax.

The *Angle* E F I, is the Moon's Horizontal Parallax when ſhe is in the Earth's Shadow in the Perigeon.

And the *Angle* E L I, the Moon's Horizontal Parallax when in the Earth's Shadow in Apogeon.

The *Angle* E D I is half the Angle of the Cone of the Earth's Shadow, equal to the apparent Semidiameter of the Sun view'd from the Top of the Shadow.

A E is the Diſtance of the Sun from the Earth; and M E the Diſtance of the New Moon: E F the Diſtance of the Full Moon in Perigeon, and E L the Diſtance of the Apegeon, full Moon: E D the Axis of the Earth's Shadow.

Draw O I parallel to A M, and H K to E F.

Having thus prepared the Work, the Sun's Horizontal Parallax will be diſcovered thus, A E C — A D C = E A I the Sun's Horizontal Parallax.

1. The Semidiameter of the Sun, leſs by his Horizontal Parallax, is equal to the Semi-angle of the Cone of the Earth's Shadow: A E C — E I A or A I O = E D I: For becauſe A E and O I are parallel, the Angle A I O = *Angle* E A I by 29th of the firſt of *Euclid.*

2. The Horizontal Parallaxes of the Moon, leſs by the Semi-angle of the Cone of the Earth's Shadow, is equal to the apparent Semidiameter of the Shadow.

E M I — E D I = F E K.

3. The Sum of the Horizontal Parallaxes of the Luminaries is equal to the Sum of the apparent Semidiameters of the Sun and Shadow of the Earth.

Angle E A I + E M I = A E C + F E K. Therefore, if from the Sum of the Horizontal Parallaxes of the Sun and Moon, you ſubtract the Sun's Semidiameter, there will remain the apparent Semidiameter of the Earth's Shadow in the Place where the Moon paſſes through. E A I + E M I, — A E C = F E K.

Thus far the Method of *Hipparchus* for finding the Sun's Horizontal Parallax, which is now determined to be no more than 10 Seconds: Therefore this Angle being ſo very ſmall, it is a very difficult Point to come at the true Diſtance of the Sun from the Earth, (I may ſay, almoſt impoſſible.) For an Eye at the Sun would behold the Earth's Semidiameter under that Angle; conſequently the Diſtance of that glorious Body from us muſt be exceeding great.

We

We can easily by Trignometry find the Length of the Earth's Shadow E D; for in the Right-angled plain Triangle E D I, there are given E I, the Earth's Semidiameter 3984.58 *English* Miles, and the Angle E D I = to the Sun's apparent Semidiameter seen from the Vertex of the Cone, which at a middle distance of the Sun from the Earth, is 16 Min. 5 Seconds, to find E D, the Length of the Earth's Shadow. Therefore I say,

	Deg. Min. Sec.	
As t. *Angle* E D I,	00 16 5	7.670043
To E I, ⊖ Semidiameter	3984 58	3.600382
So Radius,	90 00 00	10.000000
To E D, Miles.	851802	5.930339

Divide the Length of the Shadow 851802, by the Earth's Semidiameter, 3984.58, and the Quotient 214 *ferè* is the Length of the Shadow in Earth's Semidiameters. Also, if from E D you subtract E L, the Moon's Apogeon-distance, there will Remain L D, the Length of the Shadow beyond the Moon: And since the Diameter of the Earth 7969.16, is to the Diameter of the Moon 2151, as 100 to 27; therefore the Altitude of the Earth's Shadow, will be to the Altitude of the Moon's in the same Proportion; because the Conical Shadows are similar Figures; and therefore the Height of the Moon's Shadow will be 229986.54 Miles.

For, as 100 : 27 : : 851802 : 229986.54;

Which divided by 3984.58, the Earth's Semidiameter, the Quotient will be 57 $\frac{286548}{398458}$ Semidiameters of the Earth.

Secondly, The second way of finding the Horizontal Parallax, is by observing the exact Time that the Moon is in the Quadratures, which she is twice every Month: And by observing this Moment of time when she is bissected, that in the very same Moment in which the Plane of that Circle of Illumination is found in the Eye of the Spectator, or in the Center of the Earth, the Center of the Sun is in that right Line, which is perpendicular to the same Plane, and passes through the Center of the Moon. And thus you have a Right-angled plane Triangle formed by a Line supposed to be drawn from the Earth's Center to the Sun, from the Sun to the Moon, and by the Line of Illumination or Bissection of the Moon, to the Earth; and the Angle at the Sun, is that which Astronomers call, for Distinction, the *Menstrual Parallax*, or, the Difference of Position

that

that there is in the Sun, as ſeen from the Earth, and as ſeen from the Moon. The manner of obſerving the exact Moment of time when the Moon is Dechotomized, muſt be done with a very large Teleſcope, that the whole *Diſcus* of the Moon may be taken in, and her Spots repreſented to the Eye diſtinctly at one View. This being gained, they ſearch out by actual Obſervation, or by Aſtronomical Tables, the true Places of the Sun and Moon for that Moment, and their Difference of Places will be the Angle in the former Triangle formed at the Earth: And thus in the Triangle all the Angles are known, with the Diſtance of the Moon from the Earth, and conſequently the Diſtance of the Sun from the Earth is eaſily gained.

But notwithſtanding that great Subtilty of Wit and Reaſon in both theſe Methods, yet many Defects there are in them, which forbid us to expect an accurate Inveſtigation of this Parallax by means of either of them. For,

As to that of the Diagram of *Hipparchus*, there are a great many things neceſſary to be preſuppoſed; which are each of them ſo difficult to be obſerved, that we can never come to that Exactneſs as the Caſe requires. As 1. The Sun's apparent Magnitude. 2. The Horizontal Parallax of the Moon; and 3. The Semidiameter of the Shadow in the Place of the Moon's Tranſit. See Mr *Whiſton*'s Lecture, Page 70.

Thirdly, The third Method to find the Sun's Horizontal Parallax, is, by Inveſtigation of the Parallax of *Mars*, *Venus*, or *Mercury*; by *Mars*, when in oppoſition to the Sun; and by the other two, when in Conjunction Retrograde, and ſeen in the Sun's Disk: For in theſe Poſitions they are nearer the Earth, than at other times; therefore moſt proper for this purpoſe. See the firſt of theſe handled by Mr *Whiſton* in his *Aſtronomical Lecture* 7. and that of *Venus* in the Sun, by Dr *Halley*, Phil. Tranſ. N°. 348; and alſo at the end of his Obſervations, and Catalogue of the ſouthern Stars, he gives ſeveral ways to find the Parallaxes of the Sun and Moon.

Mr *Auzut* alſo gives a Method to find the Moon's Parallax, on a Day when ſhe is in her Perigee or Apogee, and in the moſt northern Signs. Thus, by taking her Diameter near the Horizon, and alſo in her greateſt Altitudes, the Difference of them will ſhew the Proportion of her Diſtance with the Semidiameter of the Earth; but this way cannot be practiſed in *England*, becauſe the Moon is never in our Zenith.

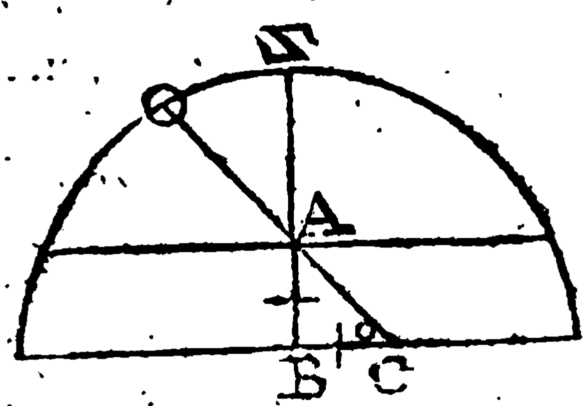
Dr *Gregory* in Vol. 1. of his *Elements of Aſtronomy*, gives in the ſeventh Section, no leſs than 19 Propoſitions for this purpoſe.

PROB. XLI.

How to make Cœlestial Observations.

To observe the true Places of the Heavenly Bodies, as of the Sun, Moon and Stars, is a Work of the greatest Importance in Astronomy; because it requires large Instruments, a good Observatory, where there is a perfect clear Horizon, a through Knowledge in Geometry, and withal, due Care in making your Observations.

At the beginning of this Section, I shewed how the Obliquity of the Ecliptic was obtained; and here I shall inform how you may take the Sun's Altitude though you be not provided with an Astronomical Quadrant: The Method is this: Take your Walking-cane or Stick, of any convenient length, and divide it into any Number of equal Parts, 10, 100, 1000, &c. Let it be straight, and set it perpendicular to the Horizon, when the Sun shines on a plain level Place. Then suppose the Stick be divided into 100 equal Parts, and I find the length of the Shadow *b c* to contain 52.6 Parts; then in the Right-angled plain Triangle A B C, Right-angled at B, there are given AB, the Height of the Stick 100 Parts, and B C, the length of the Shadow 52.6, to find the Angle A C B the apparent Altitude of the Sun.



ANALOGY, A B made Radius.

As A B the Staff height,		100	2.000000
To Radius;	90	00	10.000000
So B C the Shadow,		52.65	1.721395
To C. t. *Angle* A C B,	62	14	9.721395
Refraction sub.	00	00	27
Remains	62	13	33
Sun's Semidiameter	00	16	00
Remains	61	57	33
Parallax add	00	00	4
True Altitude of Sun	61	57	27

Hence,

Hence, because the Altitude was taken by the Shadow of the Staff, and not by the Cross-hairs in a Telescope, therefore I subtract 16 Minutes for the Sun's Semidiameter, because the Rays come from the upper Edge of the Sun, and not from the Center: But when you observe by Telescope-sights, with two Cross-hairs, then you need not use any such Deduction of the Sun's Semidiameter; because then you take the Sun's Center at once.

And *Secondly*, because it was the Sun's apparent Altitude that was observed; therefore the Refraction is subtracted, and the Parallax added; for they are always of contrary Effects. And when it is a true Altitude found by Calculation; then to that true Altitude you must add the Refraction, and deduct the Parallax, and by that means you will gain the apparent Altitude.

Secondly, *To observe the true Place of the Sun*, &c.

First, In a known Latitude, fix a large Astronomical Quadrant of 6, 8, or 10 Foot Radius (the larger the better) truly upon the Meridian, and let its Limb be truly divided into Degrees, Minutes, and Seconds, or any other Divisions, as you shall think fit; let there be a Telescope with two Cross-hairs on the Object-Glass to take the Center of the Sun, Moon, or Star when they come upon the Meridian. Then, if it is the Sun, find its true Altitude, as above has been shewn, by correcting the Apparent by Refraction and Parallax; which true Altitude, if it be less than the Elevation of the Equinoctial in the Place of Observation, then subtract the true Altitude found from the Height of the Equinoctial, and the Remainder will be the true Declination South, of the Sun, Moon, or Star, observed. But if the true Altitude exceed the Complement of your Latitude, then subtract the Complement of your Latitude from the true Altitude, and you will gain the true Declination of the Sun, Moon, or Star, observed North.

Then by *Prob.* 2. you may find the Place of the Sun, by having given the present Declination, and the Obliquity of the Ecliptic, as in that Problem I have given an Example: And as now we have a perfect Catalogue of fixed Stars, there is no Method more certain for determining the Places of the Planets, than by observing their near Appulses to the fixed Stars. See *Phil. Transf.* N°. 369.

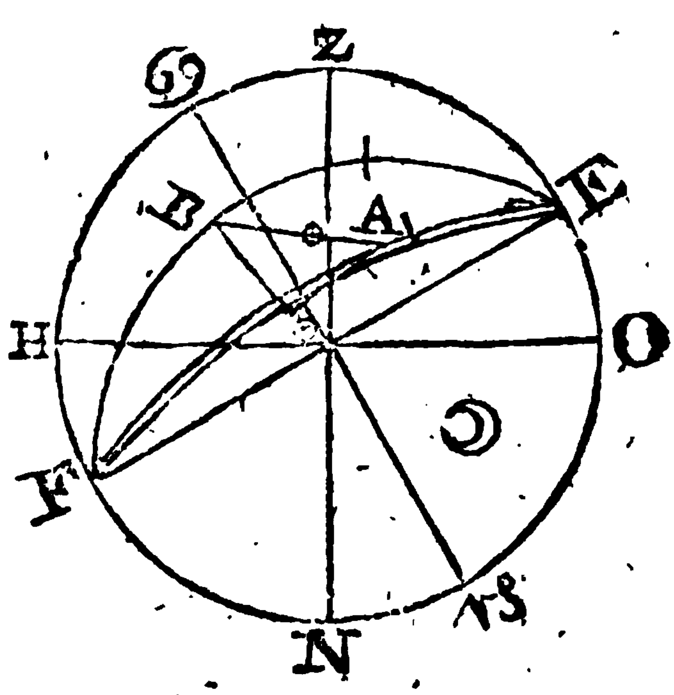
And by obſerving their Diſtances from the fixed Stars, we curiouſly gain their Places in Longitude and Latitude, as I ſhall ſhew in the next Problem.

PROB. XLII.

The Longitudes and Latitudes of the two known fixed Stars, with their Diſtance from a Planet, &c. to find the Longitude and Latitude of a Planet, Comet, or new Star.

Example. Mr *Flamſteed* in his *Hiſtoria Cælſtis*, page 412, Vol. 1, ſays that *Anno* 1688, *January* 27th, 6 Hours 44 Minutes 15 Seconds apparent Time, the Clock was then too faſt by 14 Minutes 47 Seconds, ſo the equal Time was 27 D. 6 Degrees 59 Minutes 2 Seconds, obſerved the Moon diſtant from the fixed Star called *Mirach*, or the bright Star in the Girdle of *Andromeda* 27 Degrees 13 Minutes 5 Seconds, the Longitude of *Mirach* then being ♈ 26 Degrees 33 Minutes 34 Seconds; and Latitude 25 Degrees 56 Minutes 19 Seconds North, and at the ſame Time ſhe be obſerved diſtant from *Aldebaran* 41 Degrees 13 Minutes 25 Seconds, the Longitude of *Aldebaran* was ♊ 5 Degrees 57 Minutes 50 Seconds with Latitude 5 Degrees 29 Minutes 50 Seconds South. I demand the Longitude and Latitude of the Moon at the Time of the Obſervation?

PROJECTION.



With the Chord of 60° ſweep Z H N O, to repreſent the Solſtitial Colure, H O the Horizon, ♋ ♑ the Ecliptic. Then becauſe *Mirach* is 63° 58′ 56″ from the ſaid Colure, take the Secant of 63° 58′ 56″, and draw E A F; lay off the Latitude 25 56 19 North from the Ecliptic to *A*; ſo ſhall *A* repreſent this Star in the Projection: Alſo becauſe *Aldebaran* is diſtant 24° 33′ 40″ from the ſame Colure, take the Secant thereof, and draw E B F; lay off the

the Latitude 5° 29′ 50″ from the Ecliptic South at B; so shall B represent *Aldebaran* in the Projection; from *A* and *B* draw two Circles at their Distance from the Moon, observed severally, and they will intersect at ☽; then draw E ☽ F, and compleat the Triangle A B ☽; so shall A be the Place of *Mirach*, B of *Aldebaran* observed, ☽ the Place of Moon required.

The Trigonometrical Calculation.

In the oblique angled spherical Triangle, A B E, are given A E 64° 3′ 41″ the Complement of the Latitude of *Mirach*, B E 95° 29′ 50″ the Distance of *Aldebaran*; from the North Pole of the Ecliptic, and the Angle B E A 39° 24′ 16″ the Difference of Longitude of the two Stars, to find A B, the Distance of the two known Stars. By the 10th Case of oblique angled spherical Triangles, by first letting fall a Perpendicular from A upon E B.

OPERATION.

	Deg.	*Min.*	
As C. t. A E,	64	4	9.686898
To Radius;	90	00	10.000000
So C. s. *Angle* B E A	39	24	9.888030
To t. of the 4th Arch	57	49	10.201132
From E B	95	30	
Remains 5th Arch	37	41	

Or, by Transposition say,

	Deg.	*Min.*	
As Radius	90	00	10.000000
To t. A E;	64	4	10.313102
So C. s. *Angle* B E A	39	24	9.888030
To t. fourth Arch	57	49	10.201132

Now say,

	Deg.	*Min.*	
As C. s. fourth Arch	57	49	Co. Ar. .027354
To C. s. 5;	37	41	9.898[illegible]97
So C. s. A F,	64	4	9.640804
To C. s. A B,	49	28	9.812775

Secondly,

Secondly, In the Triangle A B E, are given, all the Sides, *viz.*

	Deg.	Min.	Sec.	
B E	95	29	50	to find the Angle A B E.
A E	64	3	41	
A B	49	28	00	

Z =	209	01	31				
½ =	104	30	45		104	30	45
AB =	49	28	0	E B =	95	29	50
X =	55	2	45	X =	9	00	55

	°	′	″		°	′	″		
S E B	95	29	50	Comp.	84	30	10	Co. Ar.	0.002002
S A B					49	28	0	Co. Ar.	0.119278
S X					55	2	45		9.913607
S X					9	0	55		9.195063
								Sum	19.229950
Sine of					24	20	1		9.614975
Doubled is = A B E					48	40	2		

Or, the same Angle may be found thus:

OPERATION.

	Deg.	Min.	Sec.		
B E	95	29	50		
A E	64	3	41		
B A	49	28	00		
Z =	209	1	31		° ′ ″
½ =	104	30	45		75 29 15
A E —	64	3	41	Side opposite to required Angle.	
X	40	27	4		
S B E =	84	30	10	Co. Ar.	0.002002
S B A =	49	28	00		0.119278
S ½ Z =	75	29	15		9.985917
S X =	40	27	4		9.812110

Sum Logarithms 19.919307

Half Sum is C. s. of 24 20 0 9.9596535

Doubled is = 48 40 0 the Angle A B E.

Thirdly,

Thirdly, In the Triangle A B ☽, are given all these Sides,

		Deg.	Min.	Sec.
viz.	A B =	49	28	03
	B ☽ =	41	13	25
	A ☽ =	27	13	5
	Z =	117	54	33
	Half =	58	57	16
	A ☽ =	27	13	5 Side opposite to required Angle.
	X =	31	44	11

	Deg.	Min.	Sec.		
S. A B	49	28	3	Co. Ar.	0.119164
S. B ☽	41	13	25		0.181115
S Half Z.	58	57	16		9.932858
S. X	31	44	11		9.720995
Sum Logarithms					19.954132
Half is C f. of	18	27	56		9.977066
Double =	36	55	52	the Angle A B ☽.	
Add A B E =	48	40	00		
< E B ☽ =	85	35	52		

Fourthly, In the Triangle E B ☽ are known, B E 95° 29′ 50″, B ☽ 41° 13′ 25″, and the Angle E B ☽ 85° 35′ 32″, to find ☽ E, the Moon's distance from the North Pole of the Ecliptic, and the Angle B E ☽, the Moon's Longitude.

FIRST, For the Side E ☽, by supposing a Perpendicular let fall from ☽ upon the Side B E.

	Deg.	Min.	Sec.	
As C. t. B ☽	41	13	25	—10.057416
To Radius	90	00	00	—10.000000
So C f. *Angle* ☽ B E	85	35	52	— 8.885121
To t. of fourth Arch	3	50	5	— 8.827705

Or,

Or, by Transpoſition,

	Deg.	*Min.*	*Min.*	
As Radius	90	00	00	—10.000000
To t. B ☽;	41	13	25	— 9.942584
So C. ſ. *Ang.* ☽ BE,	85	35	52	— 8.885121
To t. of the 4*th* Ar.	3	50	5	— 8.827705
From B E	95	29	50	
Rem. 5*th* Arch	71	39	45	Complement 88 20 15

Now ſay,

	Deg.	*Min.*	*Sec.*		
As C. ſ. of the 4th Arch	3	50	5	Co. Ar.	0.000979
To C. ſ. of 5	88	20	15		8.468574
So C. ſ. B ☽	41	13	25		9.876278
To C. ſ. E ☽ Comp.	88	47	49		8.349831
From	90	00	00		
Rem. Lat. South	1	16	56		

Or, if you ſay, to the Sine of the Latitude, it will ſave the trouble of ſub. from 90.

Laſtly, For the Angle B E A;

Say, by the firſt Caſe of Spherical Triangles.

	Deg.	*Min.*	*Sec.*		
As ſ. ☽ E =	88	45	34	Co. Ar.	0.000102
To ſ. ☽ B E =	85	35	52		9.998717
So ſ. B ☽ =	41	13	25		9.818885
To ſ. B E ☽ =	41	5	15		9.817704

Hence, becauſe the Moon was in Anticedence of *Aldebaran* at B, therefore ſubtract the Angle B E ☽ from the Place of *Aldebaran* ♊ 5° 57′ 50″, and the Remainder will be the true Place of the Moon in Longitude.

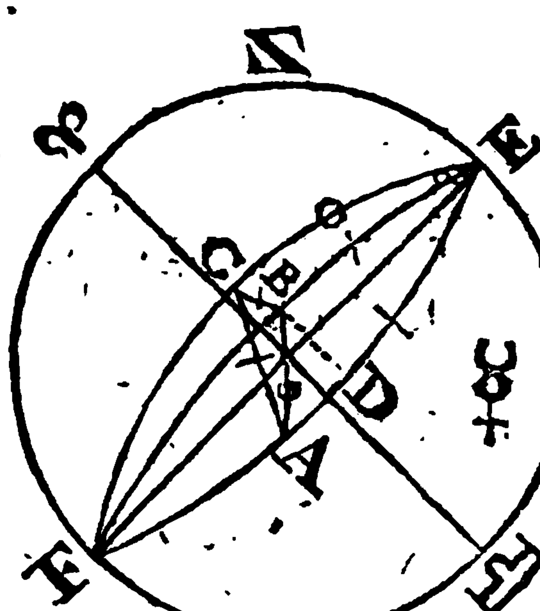
Longitude

	S.	°	′	″
Longitude of *Aldebaran*	2	5	57	50
Angle B E ☽ subtract	1	11	5	15
Rem. Longitude of the Moon	0	24	52	35

Note, If the Moon had been in Consequence of *Aldebaran*, then the Angle B E ☽ must have been added, as your own Reason will direct.

Example 2. *Anno* 1680, *April* 14*th*, at 8 h, 15′ P M, *Mercury* was observed distant from *Procyon* 55° 47′ 30″, *Procyon* at that time was in ♋ 21° 22′ 1″ having 15° 57′ 55″ south Latitude; and at the same time *Mercury* was found by Instrument to be 22° 11′ 55″ distant from the north Horn of *Taurus* or southern Foot of *Auriga*; this Star being then in ♊ 18° 5′ 36″ with 5° 21′ 34″ north Latitude, I demand the Longitude and Latitude of *Mercury* at the time of the Observation? Mr *Hogdson*'s *System, Math.* Page 452.

PROJECTION.



Because the two fixed Stars lye on each Side of the Solstitial Colure, therefore I project it on the Plane of the Equinoctial Colure; ♈ ♎ is the Ecliptic, E and F its Poles: Then because *Procyon* is 68° 37′ 59″ from ♎, take the Secant thereof, and draw EAF on which set off the Complement of its Latitude 74° 2′ 5″ from F to A; so is A the Place of *Procyon*. The manner of laying off any quantity of Degrees upon a great Circle, is the same with measuring any quantity, as is taught in p. 68, *Secondly*, Because the *Bull's Horn* is distant from *Aries* 78 deg. 5 min. 36 seconds, take the Secant thereof, and draw EBF; and set off the Complement of its Latitude 84 deg. 38 min. 26 sec. from E to B; so is B the place of the Star in the Projection. Draw two occult Circles at the distance of *Mercury*, observed

from

from A and B, ſeverally, and they will interſect at C; thro' E C and F, draw the oblique Circle and then is C the Place of *Mercury* in the Projection at the Time of the Obſervation. *Laſtly*, Draw A B, B C and C A; ſo is the Projection finiſhed. Now for the Trigonometrical Calculation, obſerve the following Steps.

Firſt, In the oblique-angled ſpherical Triangle B E A, there are given. (1.) A E, the diſtance of *Procyon* from the north Pole of the Ecliptic 105 deg. 57′ 55 ſeconds. (2.) B E the Complement of the Latitude of the Horn of *Taurus* 84 deg. 38 min. 26 ſeconds. (3.) The Angle B E A 33 deg. 16 min. 25 ſeconds the difference of the Longitude of the two known Stars, to find A B their Diſtance.

Let fall the Perpendicular B D; then in the Rect angled ſpheric Triangle E D B,

	Deg.	*Min.*	*Sec.*	
As C. t. B E,	84	38	26	8.972266
To Radius;	90	00	00	10.000000
So C. ſ. *Angle* B E D,	33	16	25	9.922237
To t, D E	83	35	51	10.949971

Or, by Tranſpoſition.

	Deg.	*Min.*	*Sec.*	
As Radius,	90	00	00	10.000000
Tot. B E;	84	38	26	11.027734
So C. ſ. *Angle* B E D	33	16	25	9.922215
To t, D E ſub.	83	35	51	10.949969
From A E,	105	57	55	
Rem. A D,	22	22	4	

Now ſay,

	Deg.	*Min.*	*Sec.*		
As C. ſ. D E,	83	35	51	Co. Ar.	0.952639
To C. ſ. D A,	22	22	4		9.966029
So C. ſ. B E,	84	38	26		8.970363
To C. ſ. B A,	39	14	19		8.889031

Secondly,

Secondly, In the oblique-angled spheric Triangle A B E are given all the Sides,

		Deg.	Min.	Sec.	
viz.	A E	105	57	55	to find the Angle B A E.
	B E	84	38	26	
	A B	39	14	19	
	Z	229	50	40	
	half	114	55	20	Complement 65° 4′ 40″
	B E Sub.	84	38	26	Side opposite to required Angle.
	X	30	16	54	

	Deg.	Min.	Sec.	
S. A E	74	2	5	Co. Ar. 0.017084
S. A B	39	14	19	Co. Ar. 0.198904
S. half Z	65	4	40	9.957550
S. X	30	16	54	9.702647
Z of the Log.				19.876185
Half is C. f.	29	52	16	9.938092
Doubled is	59	44	32	is the *Angle* B A E

The Angle B A E may be found by this *Analogy*.

	Deg.	Min.	Sec.	
As S. of the 5th Arch A D,	22	22	6	Co. Ar. 0.419578
To S. of the 4, D E;	83	35	49	9.997282
So t. *Angle* B E A of X Long.	33	16	25	9.817048
To t. *Angle* B A E,	59	44	00	10.233908

Thirdly,

Thirdly, In the oblique ſpherical Triangle A B C, are given all the Sides,

		Deg.	Min.	Sec.	
viz.	A B	39	14	19	required the Angle B A C.
	A C	55	47	30	
	B C	22	11	55	
	Z	117	13	44	
	Half	58	36	52	
	B C. ſub.——	22	11	55	Side oppoſite to Angle ſought.
	X	36	24	57	

	Deg.	Min.	Sec.		
S. A B	39	14	19	Co. Ar.	0.198904
S. A C	55	47	30	Co. Ar.	0.082495
S. half Z	58	36	52		9.931296
S. X	36	24	57		9.773524
Z Logarithm					19 986219
Half is C. ſ.	10	10	47		9.993109
Doubled is	20	21	34	the Angle B A C.	
Add *Angle* B A E	39	44	32		
Z *Angle* C A E	80	6	06		

Fourthly, In the oblique-angled ſpherical Triangle A C E, there are known, *A E*, the Diſtance of *Procyon* from the north Pole of the Ecliptic 105 Deg. 57 Min. 55 Seconds, *A C*, the obſerv'd Diſtance of *Mercury* from *Procyon* 55 Deg. 47 Min. 30 Seconds, and the included Angle *C A E* juſt now found, 80 Deg. 6 Min. 6 Seconds, to find *C E*, the Complement of *Mercury*'s Latitude, and Angle *C E A* the Longitude of *Mercury*.

Firſt,

First, For *C E*, by supposing a Perpendicular let fall from *C*, upon *A E*.

OPERATION.

	Deg.	Min.	Sec.	
As C. t. C A,	55	47	30—	9.832389
To Radius;	90	00	00—	10.000000
So C. s. *Angle* C A E	80	6	6—	9.235277
To t. of 4*th* Arch,	14	11	26—	9.402888
From A E	105	57	55	
Remains 5*th* Arch	91	46	29	Comp. 88° 13′ 31″

Or, by Transposition,

	Deg.	Min.	Sec.	
As Radius	90	00	00—	10.000000
To t. C A;	55	47	30—	10.167611
So C. s. *Angle* C A E,	80	6	06—	9.238905
To t. of 4*th* Arch,	14	11	26—	9.402888

Now say

	Deg.	Min.	Sec.		
As C. s. of 4*th* Arch,	14	11	26	Co. Ar.	0.013459
To C. s. 5;	88	13	31		8.490934
So C. s. C A,	55	47	30		9.749894
To S. Latitude Nor.	1	01	44		8.254287

For the Angle C E A.

	Deg.	Min.	Sec.		
As S. C E,	80	58	16	Co. Ar.	0.000069
To S. *Angle* C A E;	80	6	6		9.993486
So S. C A,	55	47	30		9.917505
To S. *Angle* C E A,	54	34	9		9.911060

Or

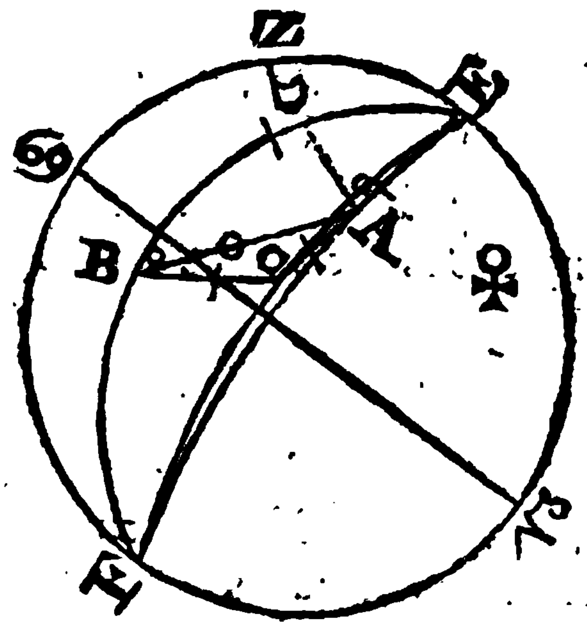
Or thus:

		Deg.	Min.	Sec.		
As S. of the 5th Arch,		88	13	31	Co. Ar.	0.000208
To S. of 4;		14	11	26		9.389428
S t. *Angle* C A E,		80	6	6		10.758212
To t. *Angle* C E A,		54	34	10		10.137846
One Sign add		30	00	00		
	S.					
Sum Sub.	1	24	34	10		
Procyon	3	21	22	1		
Place ☿	1	26	47	51		

Example 3. *Anno* 1686, *February* 11, at 6 Hours 16 Min. P. M. the Distance of *Venus* from the Head of *Andromeda* was 24 Degrees 18 Minutes 20 Seconds. The Head of *Andromeda* at that Time was in ♈ 9 Degrees 55 Minutes 33 Seconds, and Latitude 25 Degrees 41 Minutes 1 Second North. And at the same time she was distant from *Aldebaran* 46 Degrees 54 Min. 40 Seconds. The Place of *Aldebaran* was then ♊ 5 Degrees 23 Minutes 40 Seconds, with 5 Degrees 29 Minutes 49 Seconds South Latitude. I demand the Longitude and Latitude of *Venus* at the time of the Observation.

This Figure is Projected upon the Plane of the Solstitial Colure; because the Longitude of all these Stars falls between ♈ and ♋. So that ♋ ♑ is the Ecliptic, E and F its Poles; the oblique Circles *E A F* and *E B F*, are drawn by the Secants of the Distance of the Stars from the Solstitial Colure, and *E C F* as has been taught above. A is the Place of *Andromeda*,

B of *Aldebaran*, and C of *Venus*. *First*, In the oblique angled spherical Triangle A B E, are given, (1.) A E the Complement of the Latitude of the Head of *Andromeda* 64° 18′ 59″. (2.) B E the Distance of *Aldebaran* from the North Pole of the Ecliptic 95 Degrees 29 Minutes 49 Seconds. (3.) The Angle A E B the Difference of Longitude of the Head of *Andromeda* and *Aldebaran* 55 Degr. 28 Min. 7 Seconds, to find A B the Distance of the two Stars. By which I find A B to be 62 Degrees 9 Minutes, omitting Seconds.



Secondly, In the Triangle A B E, all the Sides are given.

		Deg.	*Min.*	*Sec.*	
viz.	A E	64	18	59	By which I find the Angle A B E 59 *Degrees* 4 *Minutes.*
	A B	62	9	00	
	B E	95	9	49	

Or as S. 5th Arch, to S. 4: So t. Long. to t. *Angle* A B E

Thirdly, In the Triangle A B C, all the Sides are known.

		Deg.	*Min.*	*Sec.*	
viz.	A B	62	09	00	By which I find the Angle A B C 23 *Degrees* 28 *Minutes.*
	A C	24	18	20	
	B C	46	54	40	

	°	′
To the Angle A B E	59	04
Add the Angle A B C	23	28
Sum, is the Angle C B E	82	32

Fourthly,

Fourthly, In the Triangle C B E, are known the

		Deg.	Min.	Sec.		Deg.	Min.
Sides	B E	95	29	49			
	B C	46	54	40	By which I find C E	88	21
Angle	C A E	82	32	00	And Angle C E B	46	26

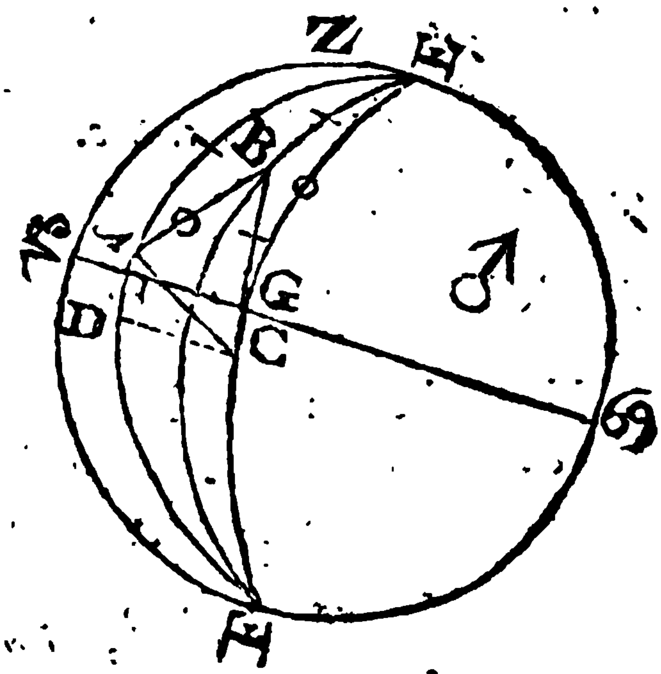
	S.	Deg.	Min.	Sec.
From Longitude of *Aldebaran*	2	5	23	40
Sub. *Angle* C E B =	1	16	26	00
Rem. Longitude ♀	0	18	57	40
With Latitude North.		1	39	0

Example 4. *Anno* 1687, *September* 29, at 6 Hours 14 Min. P. M. *Mars* was observed from the following Star of the three in the Head of *Sagittary*, 35 Degrees 41 Minutes 15 Seconds, the Star being then in ♑ 11 Degrees 54 Minutes 54 Seconds, having 1 Degree 28 Minutes 59 Seconds North Latitude. And at the same time the Distance of *Mars* was observed from the bright Star in the *Eagle* 37 Degrees 53 Minutes 30 Seconds, this Star being then in ♑ 27 Degrees 21 Minutes 34 Seconds, with 29 Degrees 19 Minutes 11 Seconds North Latitude: I demand the Longitude and Latitude of *Mars* at the time of the Observation.

In this Figure ♑ ♋, is the Ecliptic E and F its Poles, and A represents the Star in the Head of *Sagittary*, B the bright Star in the *Eagle*; their Circles of Longitude E A F and E B F, are drawn by the Secants of their distance from ♑, and C the required Place of *Mars*, by the Intersections of two Circles projected by their distance from A and B, by *Problem* 6, of spheric Geometry. In the oblique angled spheric Triangle, A B E, there are given A E, the Complement of the Latitude

of

of the first Star A, 88 Degr. 31 Minutes 1 Second, B E, the Complement of the second Star B, 60 Degrees 40 Min. 49 Seconds, and the Angle A E B being the difference of Longitude 15 Degr. 26 Min. 40 Seconds between the two known Stars, to find A B, their distance, which I find to be 31 Degr. 30 Min.



Secondly, In the Triangle A E B, all the Sides are known,

		Deg.	Min.	Sec.	
viz.	A E	88	31	1	By which I find the Angle B A E 26 *Degr.* 28 *Min.*
	A B	31	30	0	
	B E	60	40	49	

Or, As S. 5th Arch, to S. 4th; So t. Angle AEB To t. Angle B A E 26 Degrees 28 Minutes, as in Page 219.

Thirdly, In the Triangle B A E, are known the

		Deg.	Min.	Sec.	
Sides	A B	31	30	00	By which I find the Angle B A C 71 *Degr.* 36 *Min.*
	A C	35	41	15	
	B C	37	53	30	

To the Angle B A E	26	28	
Add the Angle B A C	71	36	
Sum, is Angle C A E	98	04	Compl. 81 *Degr.* 56 *Min.*

Lastly, In the Triangle C A E, are known the

		Deg.	Min.	Sec.		Deg.	Min.
Sides	C A	35	41	15	By which I find C E	93	29
	A E	88	31	1	And the Angle A E C	35	21
Angle	C A E	98	4	00			

Hence because the Perpendicular C D, falls without the Triangle, it may seem more difficult to the Young *Tyro*; therefore I shall put down the Operation.

And first, for the Segment A D.

	Deg.	Min.	
As C. t. A C,	35	41	10.143796
To Radius;	90	00	10.000000
So C. f. *Angle* D A C	81	56	9.147136
To t. A D,	5	45	9.003440
E A, add	88	31	
Z = E D	94	16	Compl. 85° 44′

Now say,

	Deg.	Min.	
As C. f. D A, the 4th Arch,	5	46	Co. Ar. 0.002191
To C. f. D E, the 5th;	85	44	8.871565
So C. f. A C,	35	41	9.909692
To S. C G Latitude South,	3	29	8.783441

Lastly, For the Angle A E C.

	Deg.	Min.	
As S. C E,	86	31	Co. Ar. 0.000803
To S. *Angle* C A E;	81	59	9.995682
So S. A C,	35	41	9.765896
To S. *Angle* A E C;	35	21	9.762381

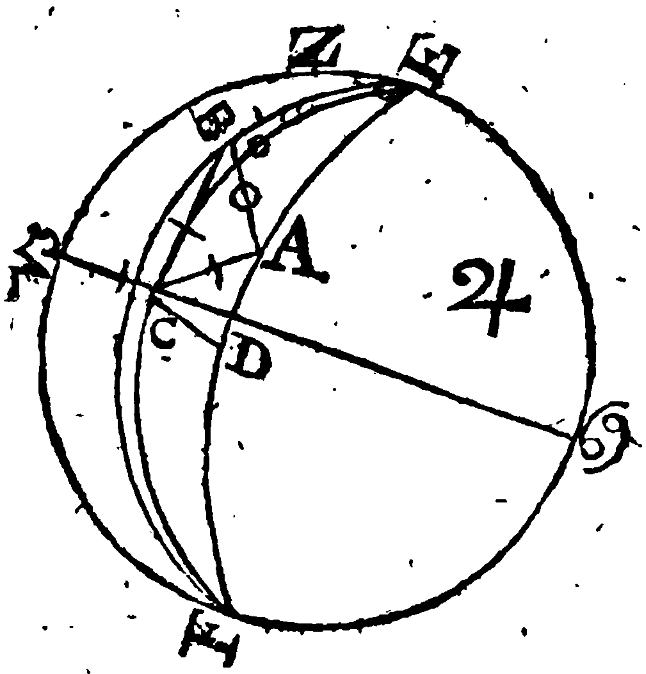
	S.	Deg.	Min.	Sec.
To the place of the Star in the Head of *Sagittary*	9	11	54	54
Add the Angle A E C,	1	5	21	00
Sum, is Longitude of *Mars*	10	17	15	54

Example

Example 5. *Anno* 1688, *August* 28, at 8 Hours 10 Min. P. M. at the Royal Observatory at *Greenwich*, the distance of *Jupiter* from the preceeding Shoulder of *Aquarius*, was measured, and found to be 32 Degrees 48 Minutes 40 Seconds the Star in *Aquarius*'s Shoulder in ♒ 19° 3′ 3″, and having 8° 38′ 43″ North Latitude; and at the same time the distance of *Jupiter* from the following of the two Stars in the *Eagle*, was found to be 36 Degrees 45 Minutes 15 Seconds; this Star was then in ♑ 15 Degrees 27 Minutes 14 Seconds, with 36 Degrees 13 Minutes 48 Seconds North Latitude. I demand the Longitude and Latitude of *Jupiter* at the Time of the Observation? A is the Place of the first Star, B of the second, and C of *Jupiter*, ♋ ♑ the Ecliptic, and E and F its Poles, E ♑ F ♋ is the Equinoctial Colure.

First, In the Oblique Angled Spheric Triangle A B E, there are known the

		Deg.	Min.	Sec.	
Sides	A E	81	21	17	By which I find the Side A B 41 *Degr.* 7 *Min.*
	B E	53	46	12	
Angle	B E A	33	35	49	



Secondly, In the Triangle A B E, are known all the Sides,

		Deg.	Min.	Sec.	
viz.	A E	81	21	17	By which I find the Angle B A E 42 *Degr.* 40 *Sec.*
	B E	53	46	12	
	A B	41	7	00	

 Thirdly,

Thirdly, In the Triangle A B C all the Sides are known,

		Deg.	Min.	Sec.	
viz.	A B	41	7	17	By which I find the Angle B A C 61 *Deg.* 54 *Min.*
	A C	32	48	40	
	B C	36	45	15	

		Deg.	Min.	
To the Angle	B A E	42	40	
Add the Angle	B A C	61	54	
Sum is the Angle	C A E	104	34	Compl. 75° 26′.

Lastly, In the Triangle A C E, are known the

		Deg.	Min.	Sec.		Deg.	Min.
Sides	A E	81	21	17			
	A C	32	48	40	By which I find C E	90	28
Angle	C A E	104	34	00	And the Angle A E C	31	38

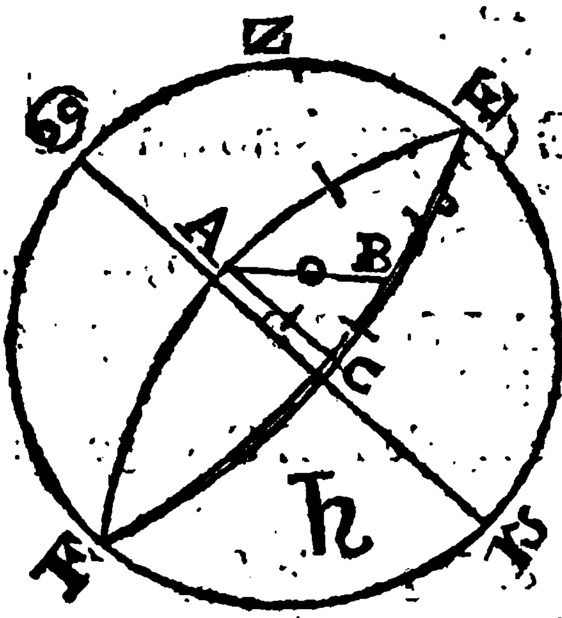
Hence, because *Jupiter* is in Antecedence of the Star A, therefore the Angle A E C 31 Degrees 38 Minutes subtracted from the Place of the Star A, will give the Place of *Jupiter* in Longitude.

	S.	Deg.	Min.	Sec.
Place of the Star A is	10	19	3	3
Angle A E C Sub.	1	1	38	00
Place of *Jupiter*	9	17	25	3
And Latitude South	00	00	28	

Example 6. *Anno* 1688, *March* 30 D. 11 Hours 40 Min. P. M. at the Royal Observatory at *Greenwich*, the distance of *Saturn* from the *Lyon*'s Heart, was found by Observation 56 Degrees 18 Minutes 15 Seconds; this Star (noted by the Letter A in the Scheme) at that time was in ♌ 25 Degrees 29 Min. 40 Seconds; and having 26 Minutes 38 Seconds North Latitude, and at the same Time the Distance of *Saturn* from *Arcturus* was found to be 28 Degrees 31 Minutes, *Arcturus* at that Time being in ♎ 19 Degrees 52 Minutes 12 Seconds, and and having 30 Degrees 57 Minutes North Latitude; this Star

in

in the Scheme is represented by B, and *Saturn* by C; I demand the Longitude and Latitude of *Saturn* at the time of the Observation.



E ♋ F ♑ represents the Solstitial Colure, ♋ ♑ the Ecliptic E and F its Poles. A the *Lyon's* Heart, B *Arctu-rus*, C the Place of *Saturn* required.

In the Oblique angled spheric Triangle A B E, there are given the

		Deg.	*Min.*	*Sec.*	
Sides	A E.	89	33	22	By which I find the Side A B 59 *Degr.* 46 *Min.*
	B E.	59	03	00	
Angle	AE B	54	22	32	

Secondly, In the Triangle A B E, are known all the

		Deg.	*Min.*	*Sec.*	
Sides, *viz.*	A B	59	46	00	By which I find the Angle B A E 53 *Degr.* 50 *Min.*
	B E	59	03	00	
	A E	89	33	22	

Thirdly, In the Triangle A B C, are given all the Sides,

		Deg.	*Min.*	*Sec.*	
viz.	A B	59	46	00	By which I find the Angle B A D 33 *Degr.* 28 *Min.*
	A C	56	18	15	
	B C	28	31	00	

To

	Deg.	Min.
To the Angle B A E	53	50
Add the Angle B A C	33	28
Sum is the Angle C A E	87	18

Lastly, In the Triangle A E C, are known the

	Deg.	Min.	Sec.		Deg.	Min.
Sides A E	89	33	22	By which I find C E	87	23
Sides A C	56	18	15	Compl. is the Lat.	2	37
Angle CAE	87	18	00	And the Angle A E C	56	17

	S.	Deg.	Min.	Sec.
To the Longitude of the *Lyon*'s Heart	4	25	29	40
Add the Angle A E C	1	26	17	00
Sum, is the Longitude of *Saturn*	6	21	46	40
With Latitude North	0	2	37	00

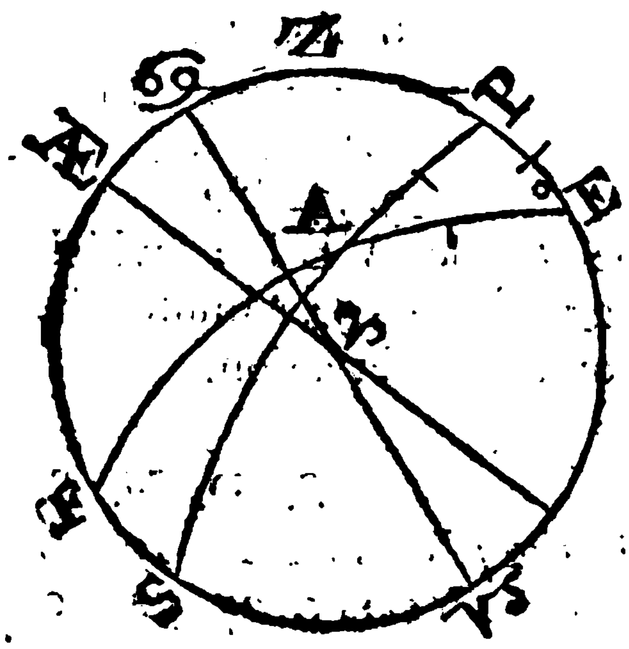
And thus have I given my Reader a full Explanation of the Method for finding the true Places of the Planets, by knowing their Distance from the fixed Stars; and by which, if he is but furnished with a good Astronomical Quadrant, and is careful to take the Distances true, he cannot miss of the true Places of the Planets; because the Method is grounded upon undeniable Principles: Which Method I have followed in Compiling the following Tables; and I doubt not but you will find the Places of the Primary Planets to agree with Observation in all Parts of their Orbits, as I have often proved: But the Moon I dare not so much boast of, for want of more Observations; for it requires no less than 194400 Observations to Compleat her Theory; that is, in every Minute of the Zodiac, and throughout one Revolution of her Apogeon. And I dare boldly affirm, that there is not any perfect Theory of the Moon extant; but in Time I hope it will be compleated.

PROB.

PROB. XLIII.

Given, the Latitude and Declination of a Star or Comet, to find its Longitude.

Example. *Anno ante Christum* 294, *Timocharis* observed (as related by *Sherbone*, Fol. 12. *V. Wing*, *Instan.* Fol. 56, and *Street*, Page 16.) the *Pleiades* to have 14 Degrees 30 Minutes North Declination, with 4 Degrees North Latitude. I demand then their true Place in Longitude?



Projection, Let P ♋ Æ ♑ represent the Solstitial Colure, Æ ♈ the Equinoctial, P and S its Poles; ♋ ♑ the Ecliptic, E and F its Poles; draw P A S, and E A F, to intersect each other at A in the given Declination and Latitude. In the oblique angled spheric Triangle A P E there are known P E, the constant Distance of the two Poles, 23 Degrees 29 Mini A P the Complement of the Declination 75 Degr. 30 Min. and A E the Complement of the Latitude 86 Degrees, to find the Angle A E P, the Longitude of the *Pleiades* from the Solstitial Colure. By the 11th Case of oblique angle spheric Triangle, the Work stands thus:

Deg

	Deg.	Min.
A E	86	00
A P	75	30
P E	23	29
Z	184	59
Half	92	29 Complement 87 *Degr.* 31 *Min.*
A P sub.	75	30
X	16	59

	Deg.	Min.		
A E S.	86	00	Co. Ar.	0.001059
P E S.	23	29	Co. Ar.	0.399591
½ Z S	87	31		9.999592
X S.	16	59		9.465522

Z of the Logarithms 19.865764
Half is C. ſ. 31 3 9.932882
Doubled, is 62 6 the Angle A E P; which ſubtracted from the Colure leaves ♈ 27 Degrees 54 Minutes the Longitude of the *Pleiades* at the time of the Obſervation.

	S.	D.	M.	S.
Longitude of the *Pleiades* after Chriſt 1727 Years	1	26	10	58
Longitude of the *Pleiades* before Chriſt 294 Years	0	27	54	00
Sum 2021	0	28	16	58

60

1696
60

2021)101818(50″

By which I prove the Annual Receſſion of the Eqninox to be 50 Seconds, as I have inſerted in the following new Tables.

See the Table of the Proceſſion of the Equinox. Vol. 2. p. 4.

PROB.

PROB. XLIV.

Given, the Latitude of the Place, and the Time of the Day or Night, to Erect a Cœlestial Scheme, according to Regiomontanus. *See* Page 189.

The principal Authors which have given their Opinions concerning the dividing of the Heavens into twelve Parts, which they call Houses, are, (1.) *Ptolemy*; (2.) *Alcabitius*; (3.) *Campanus*; (4.) *Regiomontanus*; which last is generally received, and called, *the Rational Way of* Regiomantanus.

1. *Ptolemy* advises, that the Heavens should be divided into twelve Houses by domifying Circles of Position drawn through the Poles of the Ecliptic, and through every 30 Degrees thereof, beginning to reckon at the Ascendent, and counting every 30 Degrees of the Ecliptic for the Space of one House.

2. *Alcabitius* would have the Houses of Heaven to be divided by domifying Circles, or Circles of Position drawn from the Poles of the World through every 30 Degrees of the Equinoctial, beginning at the Point of the Ecliptic Ascending; and counting 30 Degrees upon the Equinoctial from thence, to be the Cusps of the several Houses.

3. *Campanus* divides the 12 Houses by the Circles of Positions passing through each 30 Degrees of the Prime Vertical Circle, or Azimuth of East and West; and where they then cut the Ecliptic, are the Cusps of the several Houses.

4. *Regiomontanus* divides the Houses of Heaven by Circles of Position passing through the Intersection of the Meridian and Horizon, and cutting the Equinoctial in every 30 Degrees from the Ascendent, and the Point where they then cut the Ecliptic are the Cusps of the several Houses: And to find these Points of the Ecliptic, is what falls directly under the Denomination of the Doctrine of the Sphere; which, when you are acquainted readily how to perform for any time of the Day or Night, will be the only help to Learn you to know the Constellations of Heaven, and thereby readily to know any Star or Planet when you see them in the Heavens; which is the main End and Design of this and the following Problem.

Morinus, divides the Heavens by Circles of Position passing through the Poles of the Ecliptic, by which he can set a Figure of the Heavens in the Polar Circles.

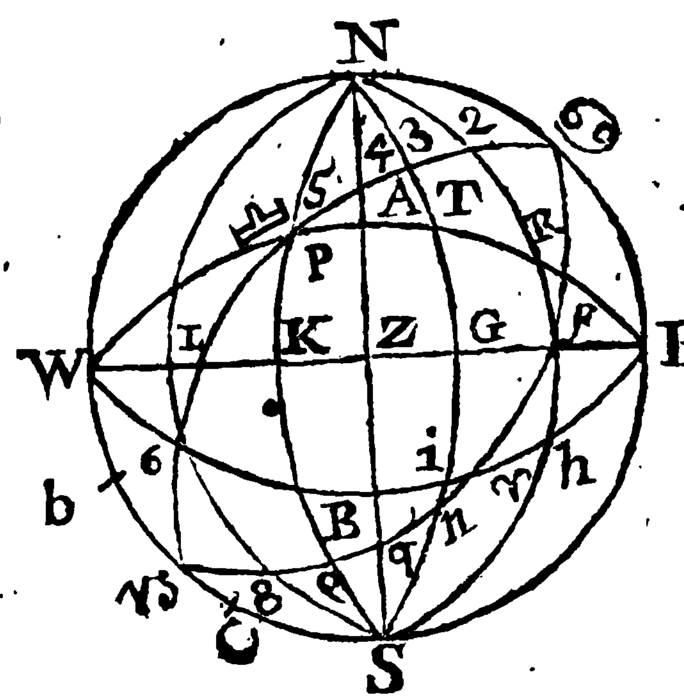
His ANALOGY is,

As Radius
To the Tangent of the Ascension of the House,
So is Co. Sine of the Obliquity,
To Tangent of the Arch in the Ecliptic.

Example. *Anno* 1728, *August* 28 Days 10 Hours 41 Min. apparent Time, at *London*; I would know the Points of the Ecliptic where the Circles of Positions intersects it; and also what Constellations and Stars are above the Horizon, and what are below it?

N. B. The Horizon is a Circle of Position for the Ascendent and Descendent, and the Meridian for the *Medium Cæli*, and *Imum Cæli*.

PROJECTION.



With any Convenient Radius of the Chord of 60 Degrees, draw the Primitive Circle N W S E, which here representeth the Horizon of the Place: N Z S the Meridian, W Z E the Prime Vertical, or East and West Azimuth. Then because the Equinoctial at *London* makes an Angle with the Horizon of 38 Degrees 28 Minutes, take the Secant thereof, and draw W A E for one half of the Equinoctial under the Horizon, and W B E for the other half above the Horizon: Then by *Prob.* 2. of spheric Geometry find the Pole of the Equinoctial W B E, which is at P; take the

the Chords of 30, and 60 Degrees severally and set them from S to C and *b*, a Ruler laid from P to C and *b*, will give the Places in the Equinoctial where the Circles of Position must cut it, and intersect the North and South Points of the Horizon at N and S.

Lastly, To draw the Ecliptic, you must by *Prob.* 34. find the Cusp of the Ascendent, and by *Prob.* 4. its Amplitude, and by *Prob.* 32. the Angle of the Ecliptic and Horizon. By help of the Chords set off the Amplitude from E to ♋, and from W to ♑, take the Secant of 31 Degrees 23 Minutes, the Angle that Ecliptic makes with the Horizon, and draw ♋ ♎ ♑ and ♋ ♈ ♑ for the Ecliptic: And where the Circles of Position N *f* S and N G S cut the Ecliptic on one Side of the Meridian, and N K S, N L S, on the other, are what we are seeking, and are vulgarly called *the Cusps of the Houses.* Now to find the said Cusps by Trigonometry, you must observe the following Steps:

First Note, in the Latitude of 51 Degrees 32 Minutes North when ♋ Ascends, the Amplitude is 39 Degrees 52 Minutes, and the Angle Orient 31 Degrees 23 Minutes. See my *Uranoscopia*, Page 291.

	D.	H.	M.	S.
Given Time Apparent 1728, *Aug.*	28	10	41	00
Equation of Time sub.		00	2	52
Equal Time	28	10	38	8
Sun's Place then	♍	16	21	54
Sun's Right Ascension		167	28	00
Apparent Time from Noon add		160	15	00
Sum, is Right A. Mid-heaven		327	43	00
Add		30	00	00
Oblique Ascension 11th House		357	43	00
Add		30	00	00
Oblique Ascension 12th		27	43	00
Add		30	00	00
Oblique Ascen. Ascendant		57	43	00
Add		30	00	00
Oblique Ascen. 2		87	43	00
Add		30	00	00
Oblique Ascension 3		117	43	00
Complement		62°	17 short of ♋	

The Work being thus prepared, the next thing to be done, is to find the Elevation of the Pole above each Circle of Position

which in the Projection are equal to the Complement of the Angles *f h* E and G *i* E; that is, the Intersection of the Equinoctial and Circles of Position.

And first, in the right angled spherical Triangle E *f h* there are given, the Angle *f* E *h*, the Latitude of the Place 51 Degrees 32 Minutes, and E *h* 30 Degrees, to find the Angle *f h* E. But here I must give you to understand, that this Triangle *h f* E, is not the Triangle it self in which the things given and required, lie; but the opposite, and consequently the Complement of the things given and required: Therefore, because a Complement falls upon a Complement (according to Lord *Neper's Catholic Proposition*) I take the Sine of *h* E, and the Tangent of the Angle *f h* E; and by Transposition, that the Radius may come first in the *Analogy*, I take the Tangent of the Angle *f* E *h*, and say for the 3d 5th, 9th and 11th Houses thus:

	Deg.	Min.
As Radius,	90	00—10.000000
To S. Circle Position from the Meridian;	30	00— 9.698970
So t. Latitude Given,	51	32—10.099913
To t. Height Pole above Circle Position,	32	11— 9.798883

Its Complement is the Angle G *i* E 57 Degrees 49 Minutes.

Secondly, For the Elevation of the Pole above the Circle of Position of the 2d, 6th, 8th and 12th Houses, in the Triangle *i* G E.

ANALOGY.

	Deg.	Min.
As Radius,	90	00—10.000000
To S. Circle Position from Meridian;	60	00— 9.937531
So t. given Latitude,	51	32—10.099913
To t. Height Pole above that Cir. Position	47	28—10.037444

Its Complement is the Angle *f h* E 42 Degrees 32 Minutes.

1. *For the Cusp of the 10th House.*

In the right angled spherical Triangle ♈ B *q*, are given, B ♈ the right Ascension of the Mid-heaven from ♈ 32° 17′ and the Angle B ♈ *q* the Obliquity of the Ecliptic, to find *q* ♈ the distance in the Ecliptic of the Cusp of the 10th from ♈.

ANA-

ANALOGY.

	Deg.	Min.
As t, B ♈, R. A.	32	17 — 9.800557
To Radius ;	90	00 — 10.000000
So C. s. *Angle* B ♈ *q*,	23	29 — 9.962453
To C. t. *q* ♈,	34	34 — 10.169896

Or, by Transposition, say,

		Deg.	Min.
As Radius,		90	00 — 10.000000
To C. t. R. A. *M. C.*		32	17 — 10.199443
So C. s. Obliquity,		23	29 — 9.962453
To C. t. of dist. from ♈	Sub.	34	34 — 10.161896
From		12	00 00
Sub. the Distance =		1	4 34
Cusp 10th House		10	25 26

2. *For the Cusp of the* 11*th House, See page* 190.

In the oblique angled spherical Triangle 11, ♈ *i*, are given *i* ♈, 2 Degrees 17 Minutes the Complement oblique Ascension from *Aries*, the Angle ♈ *i* 11, 122 Degrees 11 Minutes, and the Angle 11 ♈ *i*, the Obliquity of the Ecliptic, to find 11 ♈, that is, the Distance of the Cusp of the Eleventh in the Ecliptic from *Aries*.

By the third Axiom of oblique angled spherical Triangles the Work stands thus:

	Deg.	Min.		°	'
From a Semi-circle	180	00			
Take the Angle G *i* E	57	49			
Remain Angle ♈ *i* 11	122	11			
Angle 11 ♈ *i* add and sub.	23	29			
Sum	145	40 ½	=	72	50
Difference	98	42 ½	=	49	21
Oblique Ascension House	357	43			
Half	178	51	Compl.	1	9

Now

Now say,

	Deg.	Min.		
As S. half Z *Angles*,	72	50	Co. Ar.	0.019792
To S. half their X;	49	21		9.880072
So t. half Ob. Asc. House,	1	9		8.302634
To t. half X of 11 ♈ and 11 *i*	0	55		8.202549

Say again,

		Deg.	Min.		
As C. s. half *Angles*		72	50	Co. Ar.	0.539554
To C. s. half their X;		49	21		9.813872
So t. half Ob. Asc. House,		1	9		8.302634
To t. half Z Sides,		2	36		8.656060
Half X Sides add		0	55		
Sum, sub.	S.	3	31		
From	12	00	00		
Remains	11	26	29	Cusp 11th House; or	

Point in the Ecliptic where the Circle of Position cuts it.

3. *For the Cusp of the 12th House.*

In the oblique angled spheric Triangle ♈ *h f* are known ♈ *h*, the oblique Ascension of the 12th House 27 Degrees 43 Minutes, the Angle *f* ♈ *h*, the Obliquity 23 Degrees 29 Minutes, and the Angle ♈ *h f*, the Angle formed by the Circle of Position and Equinoctial 137 Degrees 28 Minutes, to find the Distance in the Ecliptic ♈ *f*, the Cusp of the 12th House.

OPERATION.

	Deg.	Min.		
From a Semi-circle	180	00		
Sub. *Angle f h* E	42	32		
Rem. *Angle* ♈ *h f*	137	28		
Add and Sub. *Angle f* ♈ *h*	23	29		
Sum	160	57 ½ =	80°	28′
Difference	113	59 ½ =	56	59
Oblique Ascen. House	27	43		
Half	13	51		

Now

Now say,

	Deg.	Min.	
As S. half Z *Angles*	80	28	Co. Ar. 0.006039
To S. half X	56	59	9.923509
So t. half Obli. Asc. House	13	51	9.391907
To t. half X of the Sides	11	51	9.321655

Say again,

	Deg.	Min.	
As C. s. half Z *Angles*	80	28	Co. Ar. 0.780884
To C. s. half their X;	56	59	9.736303
So t. half Ob. Asc. House,	13	51	9.391907
To t. half Z Sides,	39	2	9.909094
Add half X Sides	11	51	
Z = Side ♈ *f*. S.	50	53	

That is, 1. 20 53 the Cusp of the 12th House, or the Point of the Ecliptic where the Circle of Position cuts it. *Note* the S, stand for Signs.

4. *For the Cusp of the Ascendant.*

In the oblique angled spherical Triangle ♈ E ♋, there are given ♈ E, the oblique Ascension of the Ascendent 57 Degr. 43 Minutes, and the Angle ♈ E F = to the Latitude of the Place 51 Degrees 32 Minutes, with the Angle E ♈ ♋ = to the Obliquity of the Ecliptic 23 Degrees 29 Minutes, to find ♈ ♋ the Distance of the Cusp of the Ascendent from *Aries*.

OPERATION.

	Deg.	Min.	
From a Semi-circle	180	00	
Sub. *Angle* S E *b*	38	28	
Rem. *Angle* ♈ E ♋	141	32	
Add and Sub. *Angle* E ♈ *f*	23	29	
Sum	165	1 ½	= 82° 30′
Difference	118	3 ½	= 59 1
Oblique Asc. House	57	43	
Half	28	52	

Now

Now say,

	Deg.	Min.		
As S. half Z *Angles*,	82	30	Co. Ar.	0.003731
To S. half their X	59	1		9.933141
So t. half Oblique Asc. House	28	51		9.741066
To t. half X of the Sides	25	28		9.677938

Say again,

	Deg.	Min.		
As C. s. half Z *Angles*,	82	30	Co. Ar.	0.884302
To C. s. half their X;	59	1		9.711629
So t. half Ob. Asc. House,	28	51		9.741069
To t. half Z Sides,	65	17		10.336997
Add half X of the Sides	25	28		
X = Side ♈ ♋	90	45		
That is, ♋	00	45		

the Cusp of the Ascendent, or the Point where the Horizon cuts the Ecliptic at the given Time and Place.

5. For the Cusp of the Second House.

In the oblique angled spherical Triangle ♎ 2 R, are known, ♎ R the oblique Ascension of the House 87 Degrees 43 Min. the Angle of the Circle of Position with the Equinoctial 2 R ♎ 42 Degrees 32 Minutes, and the Angle 2 ♎ R 23 Degrees 29 Minutes, to find ♎ 2 in the Ecliptic, the Distance of the Cusp from *Libra*.

OPERATION.

	Deg.	Min.		
From a Semi-circle	180	00		
Sub. *Angle* 2 R ♎	42	32		
Rem. Obtuse *Angle* at R	137	28		
Add and Sub. *Angle* 2 ♎ R	23	29		
Sum	160	57 ½	= 80°	28′
Difference	113	59 ½	= 56	59
Oblique Asc. House	87	43		
Half	43	51		

Now

Now say,

	Deg.	Min.	
As S. half Z *Angles*,	80	28 Co. Ar.	0.006039
To S. half X,	56	59	9.923509
So t. half Oblique Afc. Houfe	43	51	9.982562
To t. half X of the Sides,	39	15	9.912110

Say again,

		Deg.	Min.	
As C. f. half Z *Angles*,		80	28 Co. Ar.	0.780884
To C. f. half their X;		56	59	9.736303
So t. half Ob. A. Houfe,		43	51	9.982562
To t. half Z Sides		72	26	10.499749
Add half X of the Sides		39	15	
Sum, from	♈	111	41	
Take away	♋	90	00	
Remains	♋	21	41	

the Cufp of the Second, or the Point of the Ecliptic where the Circle of Pofition cuts it.

Laftly, *For the Cufp of the Third Houfe:*

In the oblique angled fpheric Triangle ♎ 3 T, there are known, the oblique Afcenfion of the Houfe 117° 43′ in the Equinoctial ♎ T E, the Angle ♎ T 3 made by the Circle of Pofition and Equinoctial 57° 49′, and the Obliquity of the Ecliptic = to the Angle T ♎ 3 = 23° 29′, to find the Diftance ♎ 3 in the Ecliptic.

OPERATION.

	Deg.	Min.		
From a Semi-circle	180	00		
Take the *Angle* ♎ T 3	57	49		
Reft Obtufe *Angle* at T	122	11		
Add and fub. Obliquity	23	29		
Sum	145	40 ½	= 72°	50′
Difference	98	42 ½	= 49	21
Oblique Afc. Houfe	117	43		
Half	58	51		

Now ſay,

	Deg.	Min.		
As S. half *Angles,*	72	50	Co. Ar.	0.019792
To S. half their X;	49	21		9.880072
So t. half Ob. Aſc. Houſe,	58	51		10.218654
To t. half X Sides,	52	43		10.118518

Say again,

	Deg.	Min.		
As C. ſ. half Z *Angles,*	72	50	Co. Ar.	0.539554
To C. ſ. half their X,	49	21		9.813872
So t. half Ob. Aſc. Houſe,	58	51		10.218654
To t. half Z Sides,	75	00		10.572080
Add half X Sides,	52	43		
Sum	127	43		
Sub. 4 Signs =	120	00		
That is, ♌	7	43		

the Cuſp of the third Houſe, or the Point of the Ecliptic where the Circle of Poſition cuts it.

Thus have I given you a Method of erecting a Figure (as they call it) by the Doctrine of Triangles; in which, you are to obſerve, that if you keep in the Latitude of *London,* the half Sum of the Angles, and alſo the half Difference is unalterable, and therefore being once Collected, and to them their Sines and Co. Sines, as is here ſet down, it will greatly ſhorten the Work when you have occaſion to ſet a Scheme for the ſame Latitude.

	Houſes.		°	'		
Latit. 51° 32' North	11	3	72	50 S.	Co. Ar.	0.019792
			49	21 S.		9.880072
	Aſcend.		82	30 S.	Co. Ar.	0.003731
			59	1 S.		9.933141
	12	2	80	28 S.	Co. Ar.	0.006039
			56	59 S.		9.923509

And

And thus by the above Calculation I have found the Cuſp of the Twelve Cœleſtial Houſes to be as here follows.

			Deg.	Min.
The Cuſp of	10 Houſe is	♒	25	26
	11	♓	26	29
	12	♉	20	53
	1	♋	00	45
	2	♋	21	41
	3	♌	7	43
And the Cuſp of	4 Houſe is	♌	25	26
	5	♍	26	29
	6	♏	20	53
	7	♑	00	45
	8	♑	21	41
	9	♒	7	43

Note, You need only to calculate for the Cuſps of the ſix Houſes mentioned firſt above; for the Cuſps of the other ſix are always the ſame Degree and Minute of the oppoſite Sign.

And thus have I given you the Face of the Heavens at the Time and Place propoſed; where if it be a clear Night, and you will but take the Pains to caſt your Eyes up to the Heavens, you may ſee *Arcturus* near ſetting in the Weſt, and above him you may ſee *Hercules*, *Lyra*, the *Eagle*, and *Swan*, all North-Weſt, and on the Meridian is *Pegaſus*, the *Water-bearer*, and Planet *Saturn*; all the other Planets are under the Horizon, but *Jupiter* is near Riſing. Look South-Eaſt, and you'll ſee the *Whale*, and above him the *Ram*, and above the *Ram Andromeda*; look a little more Northerly, and you may ſee the *Bull* and *Pleiades*; above them is *Perſeus*, and above *Perſeus*, is *Caſſiopeia* in her Chair; on the Meridian between the Zenith and north Pole is *Cephas*; look a little more North, and you may ſee *Hercules* and the *Goat*, with that glittering Star *Capella* about 26 Degrees high; and between the Pole and the Horizon you have the *Great Bear*. Thus is the Spangled Canopy of Heaven, repreſented to your View at the Time and Place above-mentioned; which will be nearly ſo every 29*th* Day of *Auguſt* for this Age. But by Reaſon of the Sun's apparent annual Motion, which is about 60 Minutes a Day, the heavenly Bodies ſeems to Riſe, Culminate, and ſet about 4 Minutes ſooner every Day; becauſe one Degree is 4 Minutes in Time, which in 15 Days makes One Hour; and thus you may reckon all the Year round 15 Days

to an Hour: Which Method will ſerve well enough for common uſe to learn you to know the Conſtellation and fixed Stars; for by knowing at any time what Sign is Aſcending, Culminating and Deſcending, and then by looking into the Catalogue of Fixed Stars, you will there ſee what Stars are at that time in that part of the Heaven, a little Practice in which will make you as well acquainted with them, as you are with your familiar Friends, or with any one you know paſſing along the Street.

By the Tables of Houſes in Mr *Parker's Ephemeris*, you may readily find what Signs are in any part of the Heavens at any Time: Thus with the Sun's Place enter the Column under 10, and right againſt in the next Column on the left Hand is the Sun's Right Aſcenſion in Time, which add to the time of the Day or Night propoſed; which Sum, if leſs than 24 Hours, ſeek in the Column under the Sun's R. A. in Time; but if the Sum exceed 24 Hours, take the Overplus, and right againſt that Number towards the right Hand are the Cuſps of the 10th 11th, 12th, 1ſt, 2d, and 3d Houſes.

Example. Anno 1728, *Auguſt* 28 D. 10 h. 41′ P. M. I would know the Cuſps of the 12 Cœleſtial Houſes perform'd by the Table of Houſes?

	H.	M.	S.
Sun in ♍ 16° 21′ 54″ gives R. A. in time	11	9	52
Apparent Time from Noon add	10	41	00
Sum	21	50	52

Seek this 21 H. 50′ 52″ in the Column under A. R ☉ in Time; and right againſt it on the right Hand are the Cuſps of

			Deg.	*Min.*
the	10*th* Houſe	♒	25	26
	11*th*	♓	26	29
	12*th*	♉	20	53
	1*ſt*	♋	00	45
	2*d*	♋	21	41
	3*d*	♌	7	43

And the Cuſps of the 4*th* 5*th*, 6*th*, 7*th*, 8*th*, and 9*th* Houſes, are the ſame Degrees and Minute of the oppoſite Sign.

PROB.

PROB. XLV.

Given, the Latitude of the Place, and the Time of the Day or Night, to Erect a Cælestial Scheme by the Doctrine of Triangles, according to Regiomantus, *more Expeditiously than was shewn in the last Problem.*

First, Observe, that if the Oblique Ascension of the House be less than 90. or more than 270 Degrees; then add the Obliquity of the Ecliptic, 23 *deg.* 29 *min.* to the first Arch gives the Second.

But if the oblique Ascension of the House be more than 90, and less than 270 Degrees, then subtract the Obliquity of the Ecliptic 23° 29′ from the first Arch, gives the second.

And if the second Angle be less than 90°, the distance in the Ecliptic must be accounted from the same Equinoctial Point, that the Oblique Ascension was reckoned from.

But If the second Angle be more than 90°; then the distance in the Ecliptic must be recconed from the contrary Equinoctial Point that the Oblique Ascension of the House was reckoned from. See *Page* 190.

Example. Anno 1728, *August* 28d. 10 h. 41′ P. M. at *London*, I would know the Cusps of the Twelve Cœlestial Houses.

OPERATION.

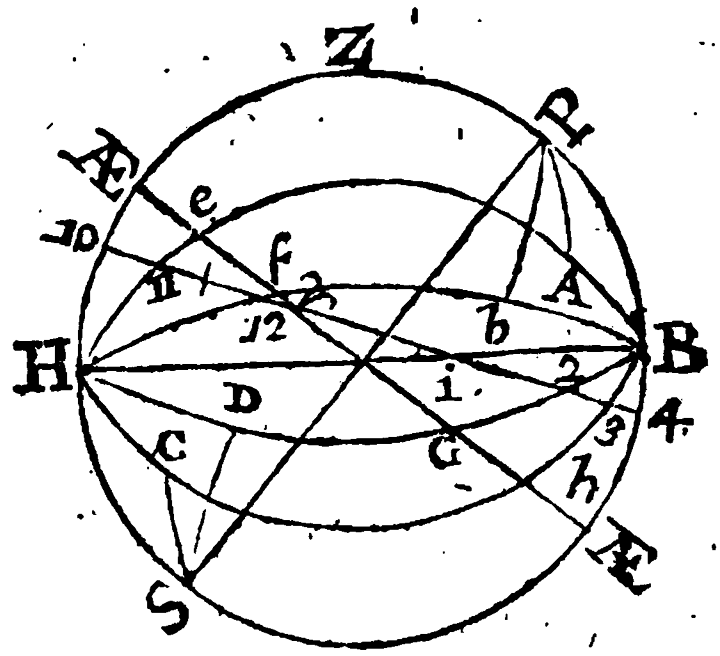
	D. H. M. S.	
Anno 1728, *August*	28 10 41	Appar. Time.
Equation of Time, sub.	2 52	
Equal Time	28 10 38 08	
Sun's Place	♍ 16 21 54	
Sun's R. A.	167 28 00	
Appar. Time from Noon add	160 15 00	
R. A. *Med. Cæli*	327 43 00	Compl. 32° 17′
Add	30 00 00	
Ob. Asc. 11*th* House	357 43 00	Compl. 2 17
Add	30 00 00	
Ob. Asc. 12*th* House	27 43 00	
Add	30 00 00	
Ob. Asc. Ascendent	57 43 00	
Add	30 00 00	

Ob.

Ob. Asc. 2d House.	87 43 00	
Add	30 00 00	
Ob. Asc. 3d House	117 43 00	Compl. 62 17

First, *For the Elevation of the Pole above each Circle of Position.*

In this Diagram P H S B, represents the Meridian of the Place, Æ Æ the Equinoctial, P and S its Poles. 10, 4, the Ecliptic, H A B a Circle of Position 30 Degrees distant from the Meridian, H *b* B a Circle of Position 60° from the Meridian above the Horizon, H D B and H C B are Circles of Position under the Horizon, cutting the Equinoctial in 30 and 60° from the Meridian at G and *h*, as the other two do at *e* and *f* above the Horizon, where they all meet at H and B, the South and north Intersections of the Horizon and Meridian, and consequently are nothing else but moveable Horizon; in which the Elevation of the Pole above those Circles of Position, are represented by P A = S C, of the 11th, 3d, 5th, and 9th Houses; to which the Angle H *e* Æ is equal: Else the Height of the Pole above those Circles of Position of the 12th, 2d, 6th, and 8th Houses is represented by P *b* = S D, to which the Angle at the Equinoctial H *f* Æ is equal: Therefore to find the Elevation of the Pole above the Circle of Position of the 11th and 3d Houses in the Rect-angled Spheric Triangle H Æ *e*, there are given H Æ, the Complement of the Latitude 38° 28′, and Æ *e* the Distance of the Circle of Position in the Equinoctial from the Meridian 30°, to find the Angle H *e* Æ.



A N A-

ANALOGY.

	Deg.	Min.	
As t. H Æ Co. Latititude,	38	28—	9.900086
To Radius;	90	00—	10.000000
So S. Æ *e*, Circle from Meridian	30	00—	9.698970
To C. t. *Angle* H *e* Æ,	57	49—	9.798884 whose

Complement 32° 11', is the Elevation of the Pole above that Circle of Position.

Secondly, For the Height of the Pole above the Circle of Position of the 12th and 2d Houses.

In the Rect-angled spheric Triangle H Æ *f*, are given H Æ, the height of the Equinoctial, or Complement of the Latitude 38° 28', and Æ *f* 60°, the distance of the Circle of Position from the Meridian, to find the Angle H *f* Æ, made by the Equinoctial and Circle of Position.

ANALOGY.

	Deg.	Min.	
As t. H Æ, Co. Latitude	38	28—	9.900086
To Radius;	90	00—	10.000000
So S. Æ *f*, Circle from Meridian,	60	00—	9.937531
To C. t. *Angle* H *f* Æ,	42	32—	10.037445

whose Complement is 47° 28', the height of the Pole above that Circle of Position.

Note, These being once found for any one Latitude, are always the same in that Latitude. And by Transposition, these Analogies will be the same as is shewed in Page 236.

Thirdly, For the Cusp of the 10th House.

In the Rect-angled spheric Triangle ♈ Æ 10, there are known Æ ♈ the Complement of the Right Ascension 32° 17', and the Angle Æ ♈ 10, the Obliquity 23° 29', to find ♈ 10 in the Ecliptic.

ANA-

ANALOGY.

	Deg.	Min.	
As t. Æ ♈. R. A. *M. Cæli,*	32	17—	9.800567
To Radius;	90	00—	10.000000
So C. s. *Angle* Æ ♈ 10,	23	29—	9.962453
To C. t. ♈ 10,	34	34—	10.161896

Or, by Transposition, as in Page 237.

	Deg.	Min.	Sec.	
From	12	00	00	
Sub. the Distance	1	04	34	
Rem. Cusp 10 in	10	25	26	the same as before.

Fourthly, for the Cusp of the 11th House.

ANALOGY.

	Deg.	Min.	
As Radius,	90	00—	10.000000
To C. s. Oblique Asc. House;	2	17—	9.999655
So C. t. Elevat. Pole above,	32	11—	10.001123
To C. t. of the first Angle,	32	12—	10.200778
Obliquity Ecliptic add	23	29	
Sum is second Angle	55	41	

Now say,

		Deg.	Min.	
As C. s. Second Angle,		55	41	Co. Ar. 0.248901
To C. s. first;		32	12	9.927469
So t. Oblique Asc. House,		2	17	8.600669
To t. of Dist. from ♈		3	26	8.777037
From	12	00	00	
Rem. Cusp 11th House ♓		26	34	

Now

Fifthly, For the Cusp of the Twelfth House.

ANALOGY.

	Deg.	Min.	
As Radius,	90	00—	10.000000
To C. f. Oblique Asc. House ;	27	43—	9.947079
So C. t. Pole above Circle, Posit.	47	28—	9.962560
To C. t. first Angle	50	55—	9.909630
Obliquity Ecliptic add	23	29	
Sum, is second Angle,	74	24	

Now say,

	Deg.	Min.		
As C. f. second Angle,	74	24	Co. Ar.	0.570377
To C. f. first	50	55		9.799651
So t. Ob. Asc. House.	27	43		9.720476
To t. past ♈	50	56		10.090630
That is, ♉	20	56	the Cusp of the Twelfth House.	

Sixthly, for the Cusp of the Ascendent,

ANALOGY.

	Deg.	Min.	
As Radius,	90	00—	10.000000
To C. f. Oblique Asc. House ;	57	43—	9.727628
So C. t. Pole above Circle Position	51	32—	9.900086
To C. t. first Angle,	67	00—	9.627714
Obliquity add	23	29	
Second Angle	90	29	Com. 89° 31′

Now say,

	Deg.	Min.		
As C. f. second Angle,	89	31	Co. Ar.	2.073781
To C. f. first ;	67	00		9.591878
So t. Oblique Asc. House,	57	43		10.199443
To t. short of ♎	89	13		11.865102

Hence, becauſe the ſecond Angle was more than 90 *deg.* this Diſtance 89 *degr.* 13 *min.* is from ♎, and not from ♈ contrary to the Oblique Aſcenſion's Diſtance.

	S.	*Deg.*	*Min.*
Therefore from	6	00	00
Sub.	2	29	13
Rem. Cuſp. Aſcend.	3	00	47

Seventhly, For the Cuſp of the ſecond Houſe.

ANALOGY.

	Deg.	*Min.*
As Radius,	90	00—10.000000
To C. ſ. Oblique Aſc. Houſe ;	87	43— 8.600332
So C. t. Pole above Circle Poſit.	47	28— 9.962560
To C. t. of the firſt Angle,	87	55— 8.562892
Obliquity add	23	29
Sum, is Second Angle,	111	24 Com. 68° 36′

Now ſay,

		Deg.	*Min.*		
As C. ſ. ſecond Angle		68	36	Co. Ar.	0.437854
To C. ſ. firſt		87	55		8.560540
So t. Ob. Aſc. Houſe		87	43		11.399322
To t. ſhort of ♎		68	11		10.397717
From *Libra*	6	00	00		
Sub.	2	8	11		
Cuſp. 2d Houſe	3	21	49		

Laſtly, For the Cuſp of the 3d Houſe.

ANALOGY.

	Deg.	*Min.*
As Radius,	90	00—10.000000
To C. ſ. Ob. Aſc. Houſe ;	62	17— 9.667545
So C. t. Pole above Circle Poſit.	32	11—10.201123
To C. t. firſt Angle,	53	32— 9.868668
Obliquity Sub.	23	29
Rem. Second Angle	30	3

Now

Now say,

		Deg.	Min.		
As C. f. second Angle,		30	3	Co. Ar.	0.062687
To C. f. first;		53	32		9.774046
So t. Ob. Asc. House;		62	17		10.269524
To t. from ♎		52	34		10.116257
From *Libra*.	6	0	0		
Sub.	1	22	34		
Rem.	♌	7	26	Cusp of the 3d House.	

And thus you may expeditiously and exactly know at any Time and Place the true Face of the Heavens.

PROB. XLVI.

Given, the Latitude of the Place, and the Distances in the Equinoctial, to calculate Hour-lines upon all sorts of Planes that have Centers.

For the Number of Planes. See *Page* 144.

I do not intend in this Place to teach you the whole Art of Dialling, (for that would take up a Volume of it self,) but only to shew the Reason of such Analogies as relate to Central Dials, that falling directly under the Doctrine of the Sphere. *See my Mechanic Dialling lately published.*

First, For the Horizontal Hour-lines.

In the Projection of the Sphere, *Prob.* 4, *Page* 98, in the Rect-angled spheric Triangle C 12, 1, are given C 12, the Elevation of the Pole above the Horizon, equal to the Latitude of the Place 51° 32′, and the Angle 12 C 1 the Distance of one Hour in the Equinoctial 15°, to find the Side 12, 1, the Distance of one Hour-line upon the Plane of the Horizon.

ANA-

ANALOGY.

	Deg.	Min.	
As C. t. *Angle* P,	15	00	10.571947
To Radious;	90	00	10.000000
So S. P 12 the Lat.	51	32	9.893745
To t. 12, 1 upon the Plane	11	51	9.321798

Or, by Transposition,

	Deg.	Min.	
As Radius,	90	00	10.000000
To S. Latitude;	51	32	9.893745
So t. Dist. in Equinoctial,	15	00	9.328052
To t. Dist. upon the Plane,	11	51	9.321797

And after this manner is the Table in *Page* 102, calculated, being Hours, Halves, and Quarters on the Horizontal Plane for the Latitude of 51° 32′.

2. For an Erect Direct Dial.

This Plane is represented by the Line 6, 6, and in the Rect-angled spheric Triangle Z P 1, are given Z P, the Zenith Distance or Complement of the Latitude of the Place, and the Angle Z P 1 = to the Equinoctial Distances of the Hour of one from the Meridian 15°, to find the Distance of the One o'Clock Hour-Line from z, in the Plane 6, 6,

ANALOGY.

	Deg.	Min.	
As C. t. *Angle* at P,	15	00	10.571947
To Radius;	90	00	10.000000
So S. P. Z,	38	28	9.793832
To t. of Hour from Z,	9	28	9.221885

Or,

Or, by Transposition,

	Deg.	Min.	
As Radius,	90	00	10.000000
To C. s. Latitude ;	51	32	9.793832
So t. *Angle* at the Pole,	15	00	9.428052
To t. one the Plane,	9	28	9.221884

And after the same manner are the Hour-distances in the Table, *Page* 103, calculated.

3. For Erect Decliners.

In *Page* 143, I have shewn you how to take the Declination of a Plane ; and when that is found, there are three other Requisites to be known, before you can draw the Hour-lines.

1. The Inclination of the Meridian of the Plane, with the Meridian of the Place.
2. The Height of the Pole, or Stile above the Place.
3. The Distance of the Substile from the Meridian Line.

And when these Requisites are found, then the next thing to find, is the distance of each Hour-line from the Substiler-Line.

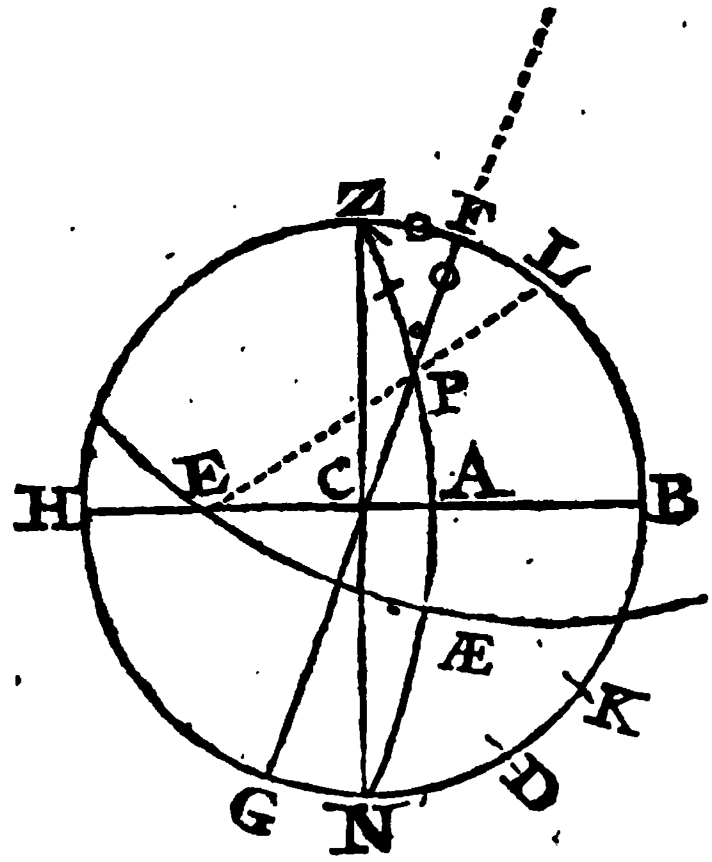
Example. Latitude 51° 32ʹ North, Declination of the Plane 29° 8ʹ East. I demand all the Requisites for drawing Hour-lines upon such a Plane ?

Projection. With the Chord of 60 sweep the Primitive Circle, which shall represent the Dial's Plane.

Take 29° 8ʹ the Plane's Declination, and set it from N to D ; lay a Ruler from *Z* to D, and it will cut the Horizon in A, through which the Meridian of the Place must pass. Or take the Secant of the Complement of the Plane's Declination 60° 52ʹ, and that will draw the Meridian Z A N. Then by *Prob.* 2, of spheric Geometry, find the Pole of this Oblique Circle of Meridian Z A N, which is at E. Take the Chord of 51° 32ʹ the Latitude of the Place, and set it from B to L, and from N to K ; draw E L, and it will cut the Meri-

Circle

dian Z A N, in P; a Ruler laid from E to K gives Æ,; find a Center in G F. To draw E Æ the Equinoctial, lay a Ruler from P to C, and draw F G for the Subſtile or Azis of the World; and now there is the Right-angled ſpheric Triangle, Z P F Right-angled at F, in which,



Z F, is the Subſtile's Diſtance from the Meridian.
Z P, the Co. Latitude of the Place.
F P, the height of the Pole above the Plane; or Stile's Height.

And the Angle { P F Z, is the Right-angle; PZF, is the Complement Plane's Declination; FPZ, is the Plane's Difference of Longitude. }

Firſt, For the Inclination of the Meridians, or the Angle FPZ.

ANALOGY.

	Deg.	Min.	
As C. t. *Angle* P Z F	60	52	9.746132
To Radius;	90	00	10.000000
So C. ſ. Z P,	38	28	9.893745
To C. t. *Angle* Z P F	35	27	10.147613

Or, by Tranſpoſition.

	Deg.	Min.	
As Radius,	90	00	10.000000
To C. t. Declination	29	8	10.253868
So S. Latitude,	51	32	9.893745
To C. t. Inclinat.	35	27	10.147613

Or

Or say,

	Deg.	Min.	
As S. Latitude,	51	32	9.893745
To Radius;	90	00	10.000000
So t. Declination,	29	8	9.746132
To t. Inclination	35	27	9.852387

2. For the Height of the Stile P F.

ANALOGY.

	Deg.	Min.
As Radius	90	00—10.000000
So S. P Z	38	28— 9.793832
So S. *Angle* P Z F	60	52— 9.941257
To S. P F	32	54— 9.735089

Or by having found the Angle at P, you may make it an adjacent Extream, and say,

	Deg.	Min.
As C. t. Z P	38	28—10.099913
To Radius	90	00—10.000000
So C. f. *Angle* Z P F	35	27— 9.910956
To t. P F	32	54— 9.811043

3. For the Distance of the Substile from the Meridian Z F.

ANALOGY.

	Deg.	Min.
As C. t. Z P	38	28—10.099913
To Radius	90	00—10.000000
So C. f. *Angle* P Z F	60	52— 9.687389
To t. Z F	21	9— 9.587476

Or, by having the Inclinations of Meridians, or Difference of Longitude, = *Angle* Z P F; by the first hereof, you may make it an opposite Extream, and say,

Deg.

	Deg.	Min.	
As Radius	90	00—	10.000000
To S. Z P	38	28—	9.793832
So S. *Angle* Z P E	35	27—	9.763422
To S. Z F	21	9—	9.557254

Now the Requisits being found, and the Plane's Difference of Longitude F P Z 35 Degrees 27 Minutes, being more than 30 Degrees or two Hours in the Equinoctial, shews, that the Substiler-line will fall between the Hour of 9 and 10 in the Morning; because the Plane declines to the East.

And before we can Calculate the Hour-distances from the Substiler-line, we must prepare a Table of the Equinoctial Hour-distances, as follows; in the first Column put down the Hours and Quarters, so many as will fall on the Plane; and then to make the second Column, proceed thus

	Deg.	Min.
Inclination Meridians	35	27
Sub. 2 Hours=	30	00
Dist. Substiler from 10	5	27
9 o'Clock from the Meridian	45	00
Inclination Meridian Sub.	35	27
Hour of 2 from Substile	9	33 on the other Side it.

	Deg.	Min.
Then you are to Note in the Equinoctial, one Hour is	15	00
Three Quarters is	11	15
Half an Hour is	7	30
One Quarter is	3	45

Then by adding, and subtracting 3 Degrees 45 Minutes continually, I compleat the second Column of this Table, which are the Degrees and Minutes in the Equinoctial answering to every Quarter of an Hour, setting the Plane's Difference of Longitude 35 Degrees 27 Minutes in the second Column against 12 o'Clock in the first Column.

Having finished the first and second Column, the third Column is made by Calculation thus, for a Quarter before 10 o'Clock in the Forenoon.

Deg.

	Deg.	Min.	
As C. t. *Angle* at Pole	1	42—	11.527546
To Radius	90	00—	10.000000
So S. Stile's Height	32	54—	9.734939
To t. dist. on the Plane	00	55—	8.207393

Or, by Transposition say,

	Deg.	Min.	
As Radius	90	00—	10.000000
To S. Stile's Height	32	54—	9.734939
So t. *Angle* at Pole	1	42—	8.472454
To t. on the Plane	00	55—	8.207393

And after this manner are the Hour-distances on the Plane in the third Column found, which may be set upon the Dial's Plane, by help of the Line of Chords from the Substiler-line, as has been shewn in the 103d Page.

The TABLE.

Hours.		Equinoctial Distan.		Hour on the Plane.		Hours.		Equinoctial Distan.		Hours on the Plane.	
		°	'	°	'			°		°	
'	"							Merid.		Subst.	
38	12	90	0	90	0		3	1	42	0	55
	3	88	18	86	52	10	0	5	27	2	58
4	0	84	33	80	2		1	9	12	5	0
	1	80	48	73	24		2	12	57	7	7
	2	77	3	67	3		3	16	42	9	14
	3	73	18	61	5	11	0	20	27	11	26
5	0	69	33	55	32		1	24	12	13	43
	1	65	48	50	24		2	27	57	16	4
	2	62	3	45	39		3	31	42	18	33
	3	58	18	41	20	12	0	35	27	21	9
6	0	54	33	37	20		1	39	12	23	54
	1	50	48	33	40		2	42	57	26	49
	2	47	3	20	16		3	46	42	29	58
	3	43	18	27	6	1	0	50	27	33	20
7	0	39	33	24	10		1	54	14	36	59
	1	35	48	21	23		2	57	57	40	57
	2	32	3	18	47		3	61	42	45	15
	3	28	18	16	19	2	0	65	27	49	56
8	0	24	33	13	56		1	69	12	55	2
	1	20	48	11	40		2	72	57	60	33
	2	17	3	9	28		3	76	42	66	29
	3	13	18	7	19	3	0	80	27	72	48
9	0	9	23	5	13		1	84	12	79	25
	1	5	48	3	9		2	87	57	86	14
	2	2	3	1	7	38'12"		90	0	90	0

4. If your declining Plane, recline from the Zenith, then before you can draw Hour-lines thereon, you must find the new Latitude, and new Declination.

Example. In the Latitude of 51 Degrees 32 Minutes N. a Plane declines to the East, or West 24 Degrees, and reclines from the Zenith 54 Degrees; what is the new Latitude and Declination.

ANA-

ANALOGY.

	Deg.	Min.
As Radius	90	00—10.000000
To C. ſ. Declination	24	00— 9.960730
So C. t. Reclination	54	00— 9.861261
To t. of the Arch	33	34— 9.821991

Now obſerve theſe Rules, in South Recliners.

1. This fourth Tangent muſt be compared with the given Latitude, and the Complement of their Difference is the new Latitude.

	Deg.	Min.
Given Latitude	51	32
Fourth Tangent ſub.	33	34
Difference	17	58
Complement	72	2 is the new Latitude.

2. If the fourth Tangent be equal to the given Latitude, then the Difference will be nothing; and ſo the Plane will be a Polar declining Plane; and the Hour-lines are Parallel, and the Stile Parallel to the Plane.

3. If the fourth Tangent be greater than the given Latitude, then the North Pole is elevated in ſouth Decliners. But if the fourth Tangent be leſſer than the given Latitude, than the ſouth Pole is elevated in north Decliners.

2. *In North Recliners.*

Rule 1. The fourth Tangent found as before, is to be compared with the Complement of the given Latitude, and their Difference is new Latitude.

Rule 2. If the fourth Tangent be equal to the Complement of the given Latitude, that declining reclining Plane will be an Equinoctial Plane Declining.

2. *To find the New Declination.*

ANALOGY.

	Deg.	Min.
As Radius	90	00—10.000000
To C. S. of the Reclinat.	54	00— 9.769219
So S. old Declination	24	00— 9.609313
To S. new Declination	13	50— 9.378532

3. *To find the Angle made between the Meridian and Horizon.*

ANALOGY.

	Deg.	Min.
As Radius	90	00—10.000000
To S. Reclination	54	00— 9.907958
So t. of the old Declination	24	00— 9.648583
To C. t. of the Angle	70	11— 9.556541

the Angle that the Hour-line of 12 must make with the Horizon. So that a Dial made (according to the Directions above,) for the Latitude of 72 Degrees 2 Minutes North, and Declination 13 Degrees 50 Minutes, will be the true Hour-lines upon a Plane in the Latitude of 51 Degrees 32 Minutes North, Reclination 54 Degrees, and Declination 24 Degrees.

5. *Of the Direct South Recliner.*

1. If the Plane on which you are to draw Hour-lines be a Direct South Recliner.

Take the Difference between the Plane's Reclination and the Complement of the Latitude of your Habitation, and that will give you a new Latitude, where that direct reclining Plane will become an Horizontal Plane. If the Reclination be equal to the Complement of the Latitude, then the Pole has no Elevation, and those Hour-lines must be drawn as under the Equinoctial, *viz.* all Parallel by their Natural Tangents.

2. If a Plane be a direct north Recliner, and that Reclination be equal to the Latitude of the Place, add it to the Complement of the Latitude, and that Sum will be 90, for the Latitude under the Poles of the World; where you have no more

more to do, than to divide a Circle (the Equinoctial) into 24 equal Parts, and the Limbs drawn to the Center shall be the true Hour-lines on such a north reclining Plane; But, Note this by the way, that this Dial is of no use in north Latitude when the Sun is in southern Signs, nor in south Latitude when he is in northern Signs. *See my Mechanic Dialling.*

And whatever the Reclination of this north Plane be, add it to the Complement of the Latitude of your Habitation, and that shall give you a new Latitude, where it will become an Horizon-plane, the Hour-lines upon which are drawn as has been shewn in the Horizontal Dial; to which I refer you.

PROB. XLVII.

To find the true and apparent Time of the Southing of the fixed Stars and Planets.

For this purpose I have Calculated Tables of right Ascensions in Time to six Degrees of North and South Latitude, which are chiefly intended for the Planets, or those Stars whose Latitudes exceed not six Degrees: And to take out the right Ascension of the Sun, enter the Table with the Place of the Sun, the Sign on the Head and Degree in the first Column on the left Hand; and under no Degrees of Latitude, (for the Sun is always apparently in the Ecliptic) and in the Angle, or Place of meeting, you have the Hour and Minute of the Sun's right Ascension, remembring to make Proportion for the Minutes of the Sun's Place; because the Table give the right Ascension only to even Degrees of the Places of the Planets and Stars: Also enter the Tables with the Place of the Planet, and in the Column of the Degree of its Latitude (if it has any at that Time) you will have the Hour and Minute of the Planet's right Ascension, minding to make proportion both for the Planet's Longitude and Latitude, if its Place be not even Degrees. In the 163th and 164th *Pages*, I have given you a Table of 42 Eminent fixed Stars with their right Ascensions in Time; but if the Star whose Time of Southing you want to know, be not in this Table, nor its right Ascension to be had in the Tables of right Ascensions, then you must find its right Ascension by *Problem* 22 and 23.

Having gained the right Ascension of the Sun, and also of the Star or Planet, subtract the Sun's right Ascension from that

of the Star or Planet, and the Remainder is the true time of the Star's being upon the Meridian: And if the Hours are less than 12, the Time is in the Afternoon of that Day; but if more than 12, 'tis in the Morning of the following Day; because, as I told you in the *Definitions* under the Word *Day*, that Astronomical Time begins at Noon: And further Note, that if the Star's right Ascension be less than the Sun's, so that Subtraction cannot be made, then add 24 Hours to the Star's right Ascension, and out of that Sum take the Sun's right Ascension, and the Remainder will be the true Time of the Star's Southing, or Culminating, that is it will be then upon the Meridian of your Habitation.

But you must be sure to get the Place of the Sun and Planet as near to the true Time of Southing as possible, otherwise you will err 2 or 3', more or less in the true Time of the Planet's southing; and therefore before we can obtain the true Time, it is necessary to have the estimate Time of their Southing, which to know, subtract the Sun's Place from the Planet's Place in Longitude, the Remainder reduced into Time by the Table, Page 66, Vol, 2. will give you the estimate Time near enough for this purpose. To this Time, find the Longitude of the Planets, and their right Ascensions to their Places at the estimate Time will produce the true Times of their Southing.

Example. Anno 1727, *October* 10, I would know the true Time of the *Pleiades* coming to the South?

1. *For the Estimate Time.*

	S.	°	'	''				
Longit. of the *Pleiades*	1	26	11	37				
Sun's Place at Noon	6	27	33	3				
Remains	6	28	38	34	This, Red. into Time,			
	h.	'	''	'''				
is Estim. Time of South.	13	54	34	16		h.	'	''
Sun's Place then is	6	28	7	44	R. A.	13	44	28 Sub.
Right Ascension *Pleiades* 24 Hours added						27	21	20 From
Remains the true Time of Southing						13	46	52

That is, 46' 52'' past one o'Clock on the 11th Day in the Morning.

Example

Example 2. Let it be required to find the true Time of the Southing of the Head of *Medusa*, on the 5th Day of *November* 1727?

OPERATION.

		S.	°	′	″	
Long. of	*Medusa, Algol*	1	22	16	42	
	☉ that Day at Noon.	7	23	39	3	
Remains		5	28	37	39	Reduced

	H.	′	″	‴		H.	′	″	
into time is Estim. time S.	11	54	30	36					
Sun's Place then is	7	24	9	7	R. A.	15	27	4	Sub.
Right Ascension of *Algol* 24 Hours added						26	50	27	From
True Time of Southing						11	23	23	

Example 3. Let it be required to find the true Time of the Southing of *Jupiter*, *December* 6, 1727?

OPERATION.

		S.	°	′	″	
Long. of	*Jupiter*	1	22	55	2	R. Lat. 0° 59′ S. D.
	Sun	8	25	7	14	at Noon.
Remains		4	27	47	48	

	H.	′	″	‴		H.	′	″	
Reduced into Time is	9	51	11	12					
Sun's Place then	8	25	32	21	R. A.	17	40	32	Sub.
Right Ascension *Jupiter* 24 Hours added						27	22	40	From
True time Southing						9	42	8	P. M.

And after this manner are the estimate and true Times of the other Primary Planets ♄ ♂ ♀ and ☿ found; but because the Moon is swift in Motion, her Place to the estimate Time is practically found by the Logistical Logarithms.

Example. *Anno* 1727, *October* 10, I would know the true Time of the Moon's Southing?

OPE-

OPERATION.

Moon's Age 7
Multiply by .8 Tenths.

5.6
H. .6

Estimate Time 5 36 of Southing.

			°	′		°	′	
☽'s Place {10, 11} Day at Noon	10	♑	23	45	Lat.	4	22	S. D.
	11	♒	6	00		3	39	S. D.
Diurnal Motion			12	15		0	43	

Now say,

	H.	M.			H.	M.	
If	24	00	L. L. Co. Ar.	6021			
Give	12	15		6900			
What	5	36		10300			
Answ.	2	51		13221			
♑	23	45	☽'s Place 10th at Noon		H.	M.	
♑	26	36	☽'s Place at Estim. South R. A.		19	58	
♎	27	47	☉'s Place at Estim. time R. A.		13	43	
True Time of ☽'s Southing					6	15	P.M.
Add Moon's Mean Motion à ☉					0	48	
Estimate time of Southing 11th Day					7	3	

			D.	M.		D.	M.
Place ☽ {11, 12} Day at Noon	11	♒	6	0	Lat.	3	39
	12		18	6		2	48
Diurnal Motion Moon			12	6		0	51

Now

Now say,

	H.	M.				
If	24	00	L L 6021			
Give	12	06	6954			
What Estimate	7	03	9306			
Answer	3	33	12275			
☽'s Place add	6	00		H.	M.	
☽ at Estimate ♒	9	33	R. A.	20	52	
☉ at Estim. ♎	28	51	R. A.	13	47	
☽ South at				7	05	
Difference in one Day add				00	50	the 11th Day.
Estimate time				7	55	the 12th Day.

				D.	M.		D.	M.	
Place ☽	12	Day at Noon	♒	18	6	Lat.	2	48	S. D.
	13			29	52		1	51	
Diurnal Motion				11	46		0	57	

Now say,

	D.	M.				
If	24	00	L L 6021			
Give	11	46	7075			
What	7	55	8796			
Answer	3	53	11892			
☽ 12 Day	18	06		H.	M.	
☽ Eimate	21	59	R. A.	21	41	
☉ — ♎	29	53	R. A.	13	52	
☽ South at				7	49	
Difference in one Day add				0	44	
Estimate time 13 Day				8	33	

				D.	M.				
Place ☽	13	Day at Noon	♒	29	52	Lat.	1	51	S. D.
	14		♓	11	40		0	50	
Diurnal Motion ☽				11	48		1	1	

Now say,

	D.	M.		H.	M.
If	24	00	LL 6021		
Give	11	48	7063		
What	8	33	8462		
Answer	4	12	11546		
Add	29	52		H.	M.
☽ ♓	4	04	R. A,	22	26
☉ ♏	0	53	R. A.	13	54
True time ☾'s Southing				8	32

And after this manner, if you pleaſe, you may proceed for the whole Year, always taking care to get the Places of the Planets as near to the Time of Southing as poſſible, as is exemplified above.

PROB. XLVIII.

Given, the Latitude of the Place, and the Places of the Stars and Planets, to find the true Times of their Riſing.

This may be performed two Ways.

1. By ſubtracting their Semidiurnal Arch from their Time of Southing, you will have the Time of their Riſing.

2. By the following Tables of oblique Aſcenſion; for if you ſubtract the oblique Aſcenſion of the Sun, from the oblique Aſcenſion of the Planet, and to the Remainder add the Time of Sun-riſing, you will gain the true Time of the Riſing of that Star or Planet.

Example. *Anno* 1727, *October* 10, I would know the true Time of the Riſing of the *Pleiades* at *London*?

OPE-

OPERATION.

	Deg.	Min.	Sec.
Their Declination North	23	14	00
Their Aſcenſional Difference in Time	2	10	48
Add	6	0	0
Their Semidiurnal Arch ſub.	8	10	48
Their time of Southing from	13	46	52
True time of their Riſing in the Even.	5	36	4

Note, To find the Semidiural Arch of a Star or Planet, if their Declinations be North, then add the Aſcenſion Difference in Time to ſix Hours; but if the Declination be South, ſubtract, the Sum or Difference, is the Semidiurnal Arch. Or by *Prob.* 7. you may find the Semidiurnal Arch without the Aſcenſional Difference.

2. By the following Tables of Oblique Aſcenſions.

		Deg.	Min.	Sec.		H.	M.	S.
Long. of	*Pleiades* ♉	26	11	37	Ob. A.	1	20	0
	Sun ♒	28	7	44	Ob. A.	14	40	0
Remains						10	40	0
Sun riſes that Morning at *London* add						6	56	4
Sum, remains the true Time of Riſing at *London* as before.						17	36	4 in
Sub.						12		
						5	36	4

Example 2. Let it be required to find the true Time of the Riſing of *Sirius*, on the 5th Day of *November* 1727.

OPERATION.

	Deg.	Min.	Sec.	
Declination South	16	20	58	
Aſcen. Difference	21	40	0	
In Time, ſubt.	1h.	26	40	
From	6	0	0	
Semidiurnal Arch,	4	23	20	
Time of Southing	15	6	3	found by the laſt Problem.
Time of Riſing	10	32	43	

Note, That if the Declination of a Star exceed the Complement of the Latitude of your Habitation, and be of the same Name, *viz.* both North, or both South, then that Star doth not rise nor set in that Latitude: As for Instance, the Head of *Medusa*'s Declination is 39 *Degrees* 53 *Minutes* North, exceeding the Complement of the Latitude of *London* 38 *Degrees* 28 *Minutes*, proves that Star never riseth nor setteth at *London*, but has 1 *Degree* 25 *Minutes* Altitude when on the Meridian under the North Pole.

To find the Rising of the Planets by the Tables of oblique Ascensions, you must first find the estimate Time of rising, and to that Time the Places of the Sun and Planet, or as near to the Time as possible.

Having by the foregoing Problem, found the true Time of southing, enter the Table of Semidiurnal Archs in the *Appendix*, with the Longitude of the Planet; and if it has at that time little or no Latitude, you will have the Semidiurnal Arch pretty near the true; but if the Planet (whose rising is required) have considerable Latitude, as *Venus* and the *Moon* often have, then by *Problem* 21, find its Declination, observe what Sign and Degree the Sun is in when he has the same Declination with the Planet; with which take out the Semidiurnal Arch, and subtract it from the Time of Southing; and that is the estimate Time of the Planet's rising; to which Time compute the Places of the Sun and Planet, and with their Places, take out their oblique Ascension, and then proceed as has been taught above.

Example. Let the true Time of the rising of *Jupiter* be enquired, *December* 6, 1727 at *London*?

OPERATION.

	H.	M.	S.
True Time of Southing	9	42	8 P.M.
Semidiurnal Arch sub.	7	40	0
Estimate Rising	2	2	8

		Deg. Min.	*Deg. Min.*		*H. M.*
Place of	♃ ♉	22 56	Lat. 0 59 South.	Ob. Asc.	1 49
	☉ ♐	25 12		Ob. Asc.	19 51

Remains	5 58
Sun rises that Morning at	8 12 add.
True Time ♃ Rising	2 10 P. M.

N. B.

N. B. You must borrow 24 Hours to the oblique Ascension of the Planet, if it be less than the Sun's, and reject 12, as in the Example above.

Example. Let it be required to find the true Times of the Rising of the Moon at *London* 1727, on *October* 19, 20, 21, 22, 23, 24, and 25th Days? The Work stands thus;

Full Moon 19th Day at One in the Morning.

Sun sets that Night at 4 *H.* 48 *Minutes*; the time from the time of the full Moon in the Morning, to the Sun's setting that Evening is 15 *Hours* 8 *Minutes*. Then if 24 h : 48' : : 15 h. 48' : 31' 36''.

By the Logistical Logarithm.

	H.	M.		
If	24	0	LL Co. Ar.	6021
Give	0	48		969
What	15	48		5795
Answer	0	31	36''	2786

These 31 Minutes 36 Seconds added to the Time of the Sun setting 4 H. 48 Min. gives 5 Hours 19 Minutes 36 Seconds, the Estimate time of the Moon's Rising.

Now for her Place at that Time.

			Deg.	Min.	Deg.	Min.	
Place ☽ the.	19	Day at Noon	♉ 11	48	Lat. 4	0	N. A.
	20		♉ 24	22	4	36	
Diurnal Motion ☽			12	34	0	36	

Say again,

	H.	M.			H.	M.
If	24	0	L L	6021		
Give	12	34		6789		
What	5	20		10512		
Answer	2	48		13322		
☽'s Place	11	48				
☽ ♉	14	36	Ob. Asc.		0	53
☉ ♏	6	46	Ob. Asc.		16	29
Remains					9	24
Sun-rising add					7	12

True

	H.	M.	
True Time Moon-rising	4	36	P. M. the 19 Day.
Diurnal Motion ☽ à ☉ add	0	48	
Estimate Rising 20 Day	5	24	

				D.	M.		D.	M.	
Place the ☽	20	Day at Noon	♉	24	22	Lat.	4	36	N.
	21		♊	7	7		4	58	
Diurnal Motion ☽				12	45		0	22	

Now say,

	H.	D.			H.	M.	
If	24	0	L L 6021				
Give	12	45	6726				
What	5	24	10451				
Answer	2	52	13198				
☽ add	24	22					
☽ ♉	27	14	Ob. Asc.		1	18	
☉ ♏	17	42	Ob. Asc.		15	35	
Remains					9	43	
Sun's Rising add					7	14	
True Time ☽ Rising					4	57	P. M. the 20 Day.
Difference of Rising add					0	21	
Estimate Time ☽ Rising					5	18	the next Day.

For the Moon's Place at that Time.

				D.	M.				
Place the ☽	21	Day at Noon	♊	7	7	Lat.	4	58	N.
	22		♊	20	6		5	7	
Diurnal Motion ☽				12	59		0	9	

	H.	M.		H.	M.	
If	24	00	LL. 6021			
Give	12	59	6948			
What	5	18	10539			
Answer	2	52	13208			
☽ 21 Day	7	7				
☽ ♊	9	59	Ob. Asc.	1	51	
☉ ♏	8	46	Ob. Asc.	15	41	
Remains				10	10	
Sun Rising add				7	15	
True time ☽ Rising				5	25	P. M. the 21 Day.
Difference of Rising add				0	28	
Estimate ☽ Rising				5	53	the next Day.

For

For the Moon's Place at that Time.

				D.	M.		D.	M.	
Place ☽ the	22	Day at Noon	♊	20	6	Lat.	5	7	N.
	23		♋	3	17		4	59	
Diurnal Motion ☽				13	11		0	8	

	H.	M.		H.	M.
If	24	00 LL	6021		
Give	13	11	6581		
What	5	53	10085		
Answer	3	14	12687		
☽ 22 Day	20	6		H.	M.
☽ ♊	23	20	Ob. Asc.	2	38
☉ ♏	9	47	Ob. Asc.	15	47
Remains				10	51
Sun-rising add				7	17
True time ☽ Rising				6	8 P.M. the 22 Day.
Difference of Rising add				0	43
Estimate time ☽ Rising				6	51 the next Day.

For the Moon's Place at that Time.

				D.	M.		D.	M.	
Place ☽ the	23	Day at Noon	♋	3	17	Lat.	4	59	N.
	24			16	41		4	35	
Diurnal Motion ☽				13	24		0	24	

	H.	M.		H.	M.
If	24	00 LL	6021		
Give	13	24	6510		
What	6	51	9425		
Answer	3	49	11956		
☽ 23 Day	3	17		H.	M.
☽ ♋	7	6	Ob. Asc.	3	42
☉ ♍	10	50	Ob. Asc.	15	3
Remains				11	49
Sun-rising add				7	19
True time ☽ Rising				7	8 P.M. the 23 Day.
Difference of Rising add				1	00
Estimate Time ☽ Rising				8	08 the next Day.

For

For the Moon's Place at that Time.

				D.	M.		D.	M.	
Place the ☽	24	Day at Noon	♋	16	41	Lat.	4	35	N.
	25		♌	0	16		3	54	
Diurnal Motion ☽.				13	35		0	41	

	H.	M.		H.	M.
If	24	0 L L 6021			
Give	13	35 6451			
What	8	8 8679			
Answer	4	36 11151			
☾ 24 Day	16	41			
☾ in ♋	21	17	Ob. Asc.	5	3
☉ in ♏	11	55	Ob. Asc.	16	0
Remains				13	3
Sun-rising add				7	21
True time ☽ Rising				8	24 P. M. the 24th Day.
Difference of Rising add				1	16
Estimate Time ☽ Rising				9	40 the next Day.

For the Moon's Place at that Time.

				D.	M.		D.	M.	
Place the ☽	25	Day at Noon	♌	0	16	Lat.	3	54	N.
	26			14	6		2	59	
Diurnal Motion ☽				13	50		0	55	

	H.	M.		H.	M.
If	24	0 L.L Co. Ar. 6021			
Give	13	50 6372			
What	9	40 7929			
Answer	5	34 10322			
☽ 25 Day	0	16			
☽ in ♌	5	50	Ob. Asc.	6	31
☉ in ♏	12	58	Ob. Asc.	16	6
Remains				14	25
Sun-rising add				7	23
True Time ☽ Rising				9	48 P. M. the 25 Day.

In the Examples above I have all along omitted Seconds, which is the practical Method of finding the Rising of the Moon; but if you would be more curious, then you may by the foregoing Problems find the true oblique Ascensions of the Sun

Sun and Moon to the given Latitude, and from thence her true Time of Rising in Hours, Minutes, and Seconds. As, for Instance, that we may have the true Time more exact, we must calculate the true Places of the Sun and Moon to the Time above found, *viz.* at 9 *Hours* 41 *Minutes*, with the other Requisites, as is here set down.

	Deg.	*Min.*	*Sec.*	
Sun's Place ♏	12	58	23	
Declination South	15	46	00	
Ascen. Differ.	20	45	00	
Right Ascen.	220	22	00	
Ob. Ascen.	241	07	00	
Time Sun's Rising	4	37	00	
Setting	7	23	00	
Moon's Longitude ♌	6	00	00	
Latitude North	3	34	00	
Declination North	22	16	00	
Ascen. Differ.	31	01	00	
Right Ascension	128	23	00	
Oblique Ascension	097	22	00	
Moon's Right Asc.	128	23	0	+ 360
Sun's Right Asc.	220	22	0	
Moon Southing	268	1	0	
	H.	*M.*	*S.*	
In Time	17	52	4	
Sun's Place then ♏	13	19		
Right Ascen.	220	51		
Moon's Place ♌	10	34		
Latitude North	3	13		
Right Ascension	133	46 + 360°.		
Sun's R. A. Sub.	220	51		
Moon's Southing	272	55		
In Time	18	11	40 P.M.	
Oblique Ascen. ☽	97	22 + 360°.		
Oblique Ascen. ☉	241	7		
Remains	216	15		
In Time ⇒	14	25 The same as by		
the Tables of Oblique Ascensions.	7	23 Sun rising add		
Sum	21	48		
Reject	12	00		
1727 *October* 25 ☽ rises	9	48 P.M.		

But

	H.	M.	S.
But, to a Quadrant or	6	00	00
Add Asc. Differ.	2	04	04
Semidiurnal Arch ☽	8	04	04
Southing	18	11	40
True time ☽ Rising	10	07	36

Thirdly, The true Time of the Rising of the Planets may be obtained, if you subtract the Sun's right Ascension from the oblique Ascension of the Planet; and if the Required exceed six Hours, take the Overplus; but if the Remainder be less than six Hours, add six Hours thereto; the Sum or Difference is the Hour and Minute of the Rising.

Example. *In the last Work of the Moon.*

	H.	M.	
☽ Oblique Ascen.	6	31	
☉ Right Ascen.	14	42	
Rem. ☽ Rising	9	49	as before.

What I have shewn above concerning the Rising of the Heavenly Bodies, has been in respect of true Time; but, by reason of Refractions and Parallaxes, that the true Time so found is not the apparent Time, or the Time that you see: Therefore to obtain the apparent Time of their Rising, regard must be had both to Refraction and Parallax; and as the Stars are raised by Refraction, and depressed by Parallax, their Effects are always contrary; so that the apparent Time will always differ from the true, except when the Refraction and Parallax are equal.

Example. *In the Moon to the Time last wrought.*

	D.	H.	M.	S.
Anno 1727, *October*	25	9	48	00
Mean Anomaly ☽	4	20	49	6
Horizontal Parallax			60	31
Horizontal Refraction sub.			33	00
Moon's true Altitude			27	31 when

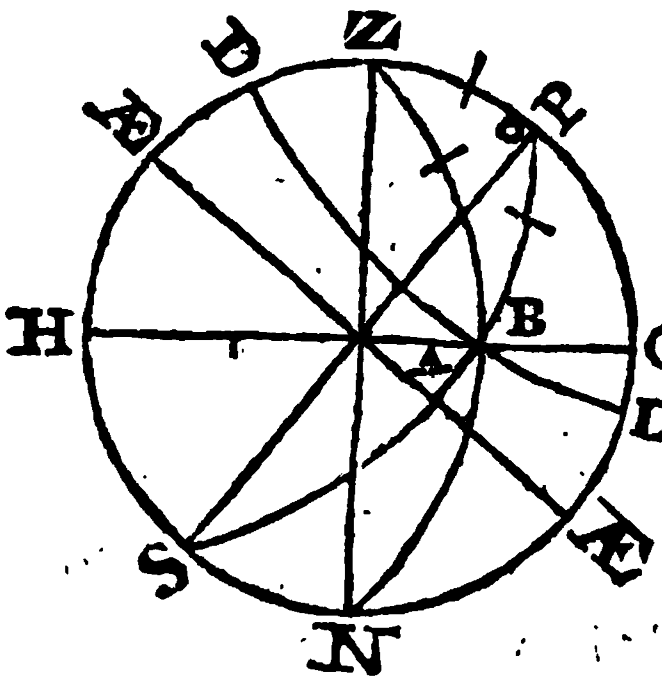
her Center begins to appear in the Horizon. Now to find the Difference of right Ascensions of the Moon and Mid-heaven, at the time of her apparent Rising, we have given the Latitude of the Place 51 *Degrees* 32 *Minutes* North, the Moon's

Moon's Declination 22 degr. 16 min. North, and the true Altitude of the Moon 27 min. 31 seconds, to find the Horary Arch of the Equinoctial. That is, in the Oblique Angled Spherical Triangle B P Z, there are given,

Z P the Complement of the Latitude 38 deg. 28 min.

B P the Complement of the Declination 67 deg. 44 min.

B Z the Complement of the Altitude 89 deg. 32 min. 29 sec. to find the Angle B P Z. the Difference of the right Ascension of the Moon, and Mid-Heaven.



OPERATION.

	Deg.	Min.	Sec.	
Z P	38	28	00	
B P	67	44	00	
B Z	89	32	29	
Z	195	44	29	
$\frac{1}{2}$	97	52	14 $\frac{1}{2}$	Compl. 82° 7′ 45″ $\frac{1}{2}$
B Z	89	32	29	
X	8	19	45	

	Deg.	Min.		
S. Z P	38	28	Co. Ar.	0.206168
S. B P	67	44	Co. Ar.	0.033656
S. $\frac{1}{2}$ Z	82	8		9.995894
S. X	8	20		9.161164
Z of the Logarithms				19.396882
$\frac{1}{2}$ Z is C. f. of	60°	3′		9.698441
Double is	120	6	the *Angle*	B P Z.

	Deg.	Min.
Moon's R. A.	128	23
Sub. *Angle* B P Z	120	6
Rem. R. A. *M. Cœli*	8	17 × 360 = 368° 17′.
Sun's Right Asc. sub.	220	22
Rem.	147	55

Time when the Moon's Center ascends the Visible Horizon = 9 h. 51′ 40″; that is, 3′ 40″ later than the Time of her real Ascent above the true Horizon.

Note, Whenever the Refraction is more than the Horizontal Parallax, then the Excess is the Depression of the Moon below the true Horizon. The Necessity of knowing the apparent Times of the Rising and Setting of the Luminaries, is in order to pronounce whether an Eclipse, or Occultation will be visible at a given Place, which by this and the Ninth Problem are performed.

If you would have the Time when the Moon's lower Limb ascends the Horizon, then add the Moon's Semidiameter, (which at that time is 16′ 26″) to her Altitude 27 min. 31 seconds, and you will have for her Altitude 43 min. 57 sec. = to A B. Then work as above has been taught.

PROB. XLXIX.

Given, the Latitude of the Place of your Habitation, and the Places of the Stars and Planets, to find the true and apparent Times of their Setting.

This (as in their Rising) may be performed two several ways; either by their Semidiurnal Arches, or by the Tables of Right and Oblique Ascensions hereunto annex'd.

1. By their Semidiurnal Arches, find the true Times of their Southing by *Prob.* 47, and then their Semidiurnal Arch as is shewn in Page 249; add these two together, and that will give the true Time of the Star's setting.

2. By the Tables of Right and Oblique Ascension, with the true Places of the Planets (as near the time as possible,) take out their Oblique Descension, which is done by entering with the

the opposite Sign and Degree of the Planet's Places, and with Latitude of contrary Name in the Tables of oblique Ascension; remembring to enter with the opposite Sign and Degree of the Sun's Place under no Degrees of Latitude; which done, subtract the oblique Descension of the Sun, from the oblique Descension of the Planet; and to the Remainder add the Time of the Sun's setting that Day, that Sum is the Time of the Planet's setting.

Or from the oblique Descension of the Planet, subtract the right Ascension of the Sun; and if the Remainder exceed six Hours, subtract six Hours from it; but if it be less than six Hours, add six Hours; the Sum or Difference is the Time of the Planet's setting.

Examples in all the Cases follows.

Anno 1727, *October* 10, I would know the true Time of the setting of the *Pleiades* at *London*?

OPERATION.

	H.	*M.*	*S.*	
To their time of Southing	13	46	52	
Add their Semidiurnal Arch	8	10	48	
Their Time of Setting	21	57	40	That is 57' 40''

past 9 in the Morning.

2. *By the Tables of Oblique Ascension.*

			Deg.	*Min.*	*Sec.*	
Long. of	*Pleiades*	♉	26	11	37	But their opposite Places are
	Sun	♎	28	28	0	

			H.	*M.*	
Pleiades ♏ 26° 11' 37''	Lat. 4° South	Ob. Desc.	17	42	
Sun ♈ 28 28 0		Ob. Desc.	0	49	
Remains			16	53	
Sun sets that Day at			5	4	
Time of their setting			21	57	as before

3. B

3. By the Tables of Right Ascensions.

OPERATION.

	H.	M.
Pleides Ob. Descension	17	42
Sun's Right Ascension	1	46
Remains	15	52
Sub.	6	0
Time of their Setting	9	56 in the Forenoon of the 11*th* Day.

Example 2. What time doth *Sirius* set at *London* the 5*th* Day of *November?*

OPERATION.

	Ho.	*Min.*	*Sec.*
Time of Southing	15	6	3
Semidiurnal Arch, add	4	33	20
Time of Setting	19	39	23

Example 3. Let the Time of *Saturn*'s setting be required at *London, October* 14, 1727?

	S.	*D.*	*M.*	
Longit. of *Saturn*	10	8	33	Lat. 0° 59′ S
Longit. of Sun	7	1	32	
Remains	3	7	1	

this Reduced into Time, is 6h. 28′ 4″ the estimate Time of Southing.

True time of Southing is	6	47	
Declination South	19	6	
Asc. Difference	25	50	
In Time	1	43	20
Semidiurnal Arch, add	4	16	40
Time of Setting	11	3	40

2. By

2. By the Tables of Right and Oblique Ascension.

		Deg.	Min.		Deg.	Min.	
Opposite Places of	♄ ♌	8	34	Latit.	0	59	North.
	☉ ♉	2	0				

	H.	Min.
♄ Ob. Desc.	7	1
☉ Ob. Desc.	0	56
Remain	6	5
Sun setting add	4	58
Saturn sets at	11	3 as before.

Or thus.

	H.	Min.
♄ Ob. Asc.	7	1
☉ R. Asc.	1	59
Remain	5	2
Add	6	0
Time of setting	11	2 as before.

Example 4. Let the Time of the Moon's setting be sought *November* 3*d*, 1727, at *London*?

New Moon the 2*d* Day at 28′ past 4 Morning.
Sun sets that Night at 4 h. 23 minutes; the Time from the New Moon is 35 h. 55 minutes.

Then if 24 h. : 48′ :: 35 h. : 55′ :: 1 h. 11′ 50″.

Sun's Setting add	4	23	00
Sum Estimate Time Moon setting	5	34	50

For the Moon's Place then,

		Deg.	Min.		Ho.	Min.	
Place ☽ the 3 Day at Noon	♐	9	4	Lat.	4	58	South.
Place ☽ the 4 Day at Noon		22	51		5	2	
Diurnal Motion Moon		13	47		0	4	

Now

Now says

	H.	M.	
If	24	00	Co. Ar. 6021
Give	13	47	6388
What	5	35	10313
Answer	3	12	12722
☽ in ♐	9	4	
☽ in ♐	12	16	
☉ in ♏	21	52	

Opposite Places are,

	D.	M.		D.	M.			H.	M.
☽ ♊	12	16	Lat.	4	59	N.	Ob. Desc.	1	58
☉ ♉	21	52					Ob. Desc.	1	40
Remain								0	18
Sun sets at								4	23
Time of the Moon's setting								4	41

Or thus:

	D.	M.		D.	M.	
☽ ♊	12	16	Ob. D.	1	58	
☉ ♉	21	52	R. A.	3	17	
Remain				10	41	
Subtract				6	00	
Moon setting				4	41	as before.

Or the estimate Time of the Moon's setting may be found by taking the R. A. of the Sun, and the Ob. A. of the Moon to their Places on the 3d Day at Noon; and their Difference, rejecting 6 *Hours*, will be 4 *Hours* 30 *Minutes*; to which time compute the true Places of the Sun and Moon, and to those Places, take out of the Tables the Right Ascension of the Sun, and the oblique Descension of the Moon, and their Difference (adding or subtracting six Hours) is the Time of the Moon's setting. But if your Case require more Exactness, you must to this time last found compute the Places of the Sun and Moon. Then working as before is taught, you will obtain the true and correct Time of the Moon's setting.

2. *To*

2. *To find the Time of the Moon's setting by her Semidiurnal Arch.*

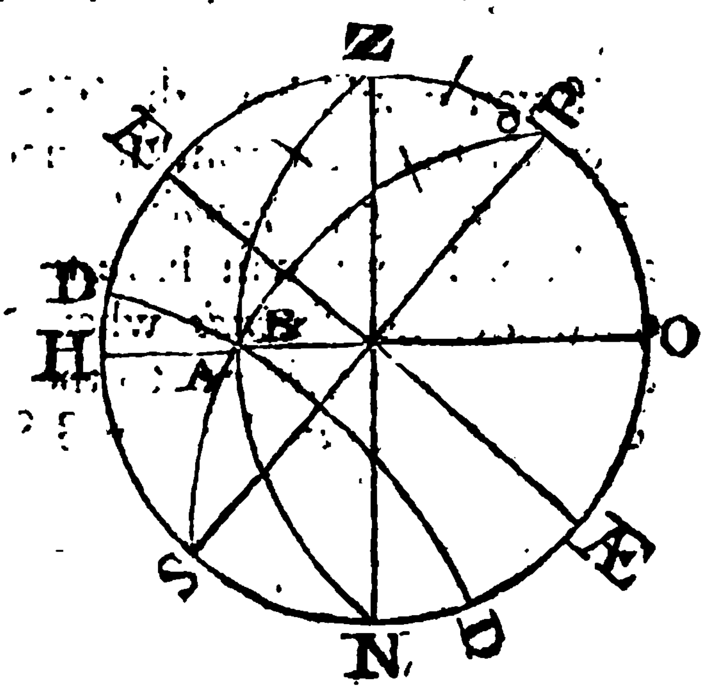
	H.	M.	
True Time of Southing	1	12	
Estimate Time of setting	4	30	
Moon's Place then ♐	11	39	Lat. 4° 59′ S.
Moon's Declination South	27	11	
Ascension Difference	40	17	11
In time Sub.	2	41	8 from 6 Hours.
Semidiurnal Arch add	3	18	52 to her Southing.
Time of Moon's setting	4	30	52

Observe, by reason of the Moon's swift Motion, her Semidiurnal Arch is always changing, which causes a Difference between the time of her rising and setting from that Time, found by the oblique Ascension or oblique Descension. But in the fixed Stars and other Planets, whose Motions are slow, their rising and setting, found by the Semidiurnal Arch, will agree with the times found by the oblique Ascensions, &c.

Lastly, I shall shew the Investigation of the apparent Times of the Moon's setting.

		H.	M.	S.
Anno 1727, *Nov.* 3, Moon sets at		4	41	00 at *London.*
Mean Anomaly Moon then	8 S.	15	37	03
Horizontal Parallax			58	41
Horizontal Refraction subtract			33	00
Moon's true Altitude			25	41 when her

Center begins to descend the Western Horizon.



Therefore, in the oblique angled spherical Triangle B Z P are given B Z, the Complement of the Altitude 89 *Degrees* 34 *Minutes* 19 *Seconds*, B P the Distance of the Moon from the North Pole of the Equinoctial 117 *Degrees* 11 *Minutes* and Z P the Complement of the Latitude 38 *Degrees* 28 *Minutes*, to find the Angle B P Z, the

Difference

Difference of the right Ascension of the Moon and Mid-Heaven.

OPERATION.

	D.	M.	S.	
Z P	38	28	0	
B P	117	11	0	Complement 62 Degr. 49 Min.
B Z	89	34	19	
Z	245	13	19	
Half	122	36	39	Complement 57 Degr. 23 Min. 21 Sec.
B Z	89	34	19	
X	33	2	20	

	D.	M.		
S. Z P	38	28	Co:Ar.	0.206168
S. B P	62	49	Co.Ar.	0.050826
S. ½ Z	57	23		9.925464
S. X	33	2		9.736497
Z of the Logarithms				19.918955
C. s. of	24	22		9.9594775
Doubled	48	44 is the Angle BPZ.		
☾ R. A. add	249	21		
Z.R.A.*M.C.*	298	5		
☉'s R. A. sub.	229	26		
Remains	68	39,		

Remains 68 39, which reduced into Time, is 4 Hours 34 Minutes 36 Seconds, the apparent Time of the Moon's descending the Western Horizon.

If you would have the Time when the Moon's upper Limb descends the Horizon, subtract her Horizontal Semidiameter 15 *Minutes* 55 *Seconds* from her Altitude 25 *Minutes* 41 *Seconds*, and you will have for the Altitude of the upper Limb 9 *Minutes* 46 *Seconds* when it leaves our Hemisphere; which by working according to the preceeding Method, I find it to set at 4 *Hours* 37 *Minutes* 8 *Seconds*.

OPERATION.

		Min.	Sec.	
Moon's Altitude when her Center descends the Western Horizon.		25	41	
Horizontal Semidiameter sub.		15	55	
Alt. of her upper Limb when setting		9	46	
From	90	0	0	
Zen. Dist. ☽ upper Limb = to BZ	89	50	14	
B P	117	11	0	Compl. 62° 49′
Z P	38	28	0	
Z	245	29	14	
half	122	44	37	Compl. 57° 15′ 23″
B *Z* subt.	89	50	14	
X	32	54	23	

	Deg.	Min.	
S. Z P	38	28	Co. Ar. 0.206168
S. B P	62	49	Co. Ar. 0.050826
S. half Z	57	15	9.924816
S. X	32	54	9.734939
Z Logarithms			19.916749
half is C. s. of	24	41	9.958374 5
Doubled is	49	22 = *Angle* B P Z, supposing that Scheme to serve for this Work.	
☽ R. A. add	249	21	
R. A. *M. C.*	298	53	
☉ R. A.	229	26	
Remains	69	17	

Remains 69 17 which in time is 4 H. 37 Min. 8 Seconds, the time that the upper Limb of the Moon descends our Horizon. And thus have I given you all the Methods of finding the rising, southing and setting of the Sun, Moon, and Stars, both true and apparent Times, which was never before so Methodically, and fully Handled by any.

PROB. L.

Given, the Latitude of the Place, and the Oblique Ascension of the Star or Planet, to find the Time when it will rise Cosmically.

Every Star rises with that Point of the Ecliptic, that has the same oblique Ascension with it: And consequently at the same time with the Sun, when he possesses that Degree of the Ecliptic.

Therefore, by *Problems* 5th and 6th, having found the oblique Ascension of the Star, subtract 90 *Degrees* from it, and the Remainder will be the right Ascension of the Mid-heaven at the time of the Star's rising: Then by the 34th *Problem* find the Cusp of the Ascendent; which done, see what Day of the Month the Sun is in that Degree of the Ecliptic that is then Ascending; for that is the Day, that the Star riseth Cosmically.

Example. Let it be required at *London* to find the Time when the *Pleiades* rise Cosmically, *Anno* 1741?

See the Work.

		Deg.	Min.	Sec.
Pleiades	Longitude ♉	26	22	38
	Latitude North	4	00	37
	Declination North	23	16	00
	Ascen. Difference sub.	32	46	00
	Right Ascension	52	50	00
	Oblique Ascension	20	4	00
	Right Asc. *M. Cœli*	290	8	00

Degree of the Ecliptic Ascending ♉ 13 *Degrees* 46 *Minutes* the Sun is in this Place of the Ecliptic about the 23d Day of *April*; on which Day the Sun and *Pleiades* rise together.

Example 2. At *London*, I would know the Day when *Fomahaunt* rises Cosmically?

Longi-

	Deg.	Min.	Sec.
Longitude of *Fomahaunt* ♒	20	56	50
Latitude South	21	4	54
Declination South	31	3	30
Asc. Difference add	49	19	0
Right Ascension	340	34	59
Oblique Ascension	29	53	59
Degr. of the Ecliptic Asc. ♉	29	31	0

The Sun is in this Place of the Ecliptic about *May* 10, which is the Day this Star rises Cosmically at *London*?

Example. 3. I demand the Day that the bright Star in the *Eagle* will rise Cosmically at *London*.

I shall put down all the Work as follows.

	Deg.	Min.	Sec.
Longitude of the Star ♑	27	54	54
Latitude	29	19	11
Declination North	8	16	15
Right Ascension	294	20	00
Ascensional Diff. sub.	10	24	00
Oblique Ascension	283	56	00 from ♈ 76° 4'.

Now by *Problem* 34, find the Point of the Ecliptic Ascending.

	Deg.	Min.	
As Radius	90	00—	10.000000
To C. s. Ob. Asc. of the Star	76	04—	9.381643
So C. t. Latitude *London*	51	32—	9.900086
To C. t. of	79	10—	9.281729
Obliquity add	23	29	
Z. is the second Angle	102	39	Complement 77° 21'

Now say,

	Deg.	Min.		
As C. s. sec. Angle	77	21	Co. Ar.	0.659566
To C. s. first	79	10		9.274049
So t. Ob. Asc. ✱	76	4		10.605386
To t. from ♎	73	53		10.539901

That

That is, ♐ 13 *Degrees* 53 *Minutes*, to which Place of the Ecliptic the Sun comes about the 25th Day of *November*, on which Day this Star rises cosmically. This Method is more Expeditious, than any ever published that I know of.

PROB. LXI.

Given, the Latitude of the Place, and the Oblique Descension of a Star, to find the Time of its Cosmical Setting.

Every Star sets with what Point of the Ecliptic that has the same Oblique Descension with it, and consequently at the same time as the Sun rises, when he possesses that opposite Point of the Ecliptic.

By *Problem* the 6th find the Oblique Descension of the Star, and add to it 180 *Degrees*; that Sum is the Oblique Ascension of the Ascendent; to which find by *Problem* 34, the Point of the Ecliptic then Ascending, and that is the Place of the Sun, at the Time that the given Star sets Cosmically.

Example. What time at *London* do the *Pleiades* set Cosmically this Year 1741?

See the Work.

	Deg.	*Min.*	*Sec.*
Longitude *Pleiades* ♉	26	22	38
Latitude	4	00	37
Declination North	23	16	00
Right Ascension	52	50	00
Ascen. Difference add	32	46	00
Sum, Oblique Descension	85	36	00
Add	180	00	00
Oblique Ascension	265	36	00
Complement past ♎	85	36	00

A

Now say, by Prob. 34.

	Deg.	Min.	
As Radius	90	00—	10·000000
To C. ſ. Ob. Aſç.	85	46—	8.868165
To C. t. Latitude	51	32—	9.900086
To C. t. of	86	39—	8.768251
Obliquity Sub.	23	29	
Rem. ſec. Angle	63	10	

	Deg.	Min.		
As C. ſ. of ſec. *Angle*	63	10	Co. Ar.	0.345442
To C. ſ. of firſt *Angle*	86	39		8.766675
So t. Ob. Aſç.	85	36		11.113815
To t. from ♎	59	16		10.225932
That is, ♏	29	16,		

to which Place the Sun comes *November* the 11th Day, and that is the Day that the *Pleiades* ſet coſmically.

Example 2. Let the Day that *Fomahaunt* ſets coſmically at *London* be required?

OPERATION.

	Deg.	Min.	Sec.
Longitude of *Fomahaunt* ♒	29	59	50
Latitude	21	4	54
Declination South	31	03	30
Right Aſcenſion	340	34	59
Aſcen. Difference	49	19	00
Oblique Deſcenſion	291	15	59
Add	180	00	00
Oblique Aſcenſion	111	15	59
Complement ſhort of ♎	68	44	1
Degree Aſcending ♌	11	51	50

to which Place of the Ecliptic the Sun comes the 24th of *July*, and that is the Day ſought.

Example 3. What Day doth the middle Star in *Orion's* Belt ſet coſmically at *London?*

A Synop.

A Synopsis of the Work.

		Deg.	Min.	Sec.
Longitude of the ✱	♊	19	38	34
Latitude South		24	33	30
Declination South		1	24	49
Right Aſcenſion		80	34	23
Aſcenſional Difference ſub.		1	47	00
Rem. Ob. Deſcenſion		78	47	23
Add		180	0	00
Oblique Aſcenſion		258	47	23
Complement paſt ♎		78	47	23
Degree Aſcending ♏		25	16	

the Sun comes to this Degree of the Ecliptic about the 6th of *November*, which is the Day ſought. What has been ſaid of the Fixed Stars, the ſame is to be obſerved of the Planets.

A TA-

A TABLE *of* 42 *Fixed Stars, with the Days when they rise and set Cosmically at* London.

STARS Names.	Cosmical Rising.	Cosmical Setting.
First in *Pegasus*'s Wing, *Marchab*	*Jan.* 1	*Sept.* 13
Right Shoulder in *Aquarius*	9	*Aug.* 18
Extream Star in the Wing of *Pegasus*	28	*Sept.* 24
Last in the *Goat*'s Tail	*Feb.* 7	*July* 31
Bright Star in the *Ram*'s Head	*March* 4	*Oct.* 24
That in the former Horn, called first ✳ ♈	10	19
In the Tail of the *Whale*	*April* 12	*Sept.* 4
The Brightest of the *Pleiades*	23	*Nov.* 12
In the *Whale*'s Mouth, *Mencar*	*May* 20	*Oct.* 15
North Horn of the *Bull*, foot of *Auriga*	15	*Nov.* 10
Fomahaunt	*May* 10	*July* 24
North Eye of the *Bull*	20	*Nov.* 13
In the Belly of the *Whale*	23	*Sept.* 12
South Eye of the *Bull*, *Aldebaran*	28	*Nov.* 13
South Horn of the *Bull*	*June* 5	30
Castor	9	*Feb.* 3
Pollux	22	*Jan.* 19
Middle Star in *Orion*'s Belt	*July* 3	*Nov.* 6
Lesser Dog, Procyon	19	*Dec.* 7
In the *Hare*'s Thigh	22	*Oct.* 18
In the *Great Dog*'s Mouth *Syrius*	31	*Nov.* 5
Lyon's Heart	*August* 9	*Feb.* 13
Lyon's Back	16	*April* 16
Hydra's Heart	20	*Dec.* 17
In the Tail of the *Lyon* *Deneb.*	22	*April* 15
Vindemiatrix	*Sept.* 10	*May* 7
Arcturus	15	*June* 12
Virgin's Girdle	19	*April* 19
Bright Star of the *Crown*	28	*July* 9
Virgin's Spike	*Oct.* 4	*March* 27
Right Shoulder of *Hercules*	6	*July* 12
Left Shoulder of *Hercules*	10	25
Head of *Hercules*	21	11
Swan's Bill	30	*Aug.* 21
Right Shoulder of *Ophiucus, Serpentarius*	*Nov* 5	*July* 7
Lower Wing of the *Swan*	5	*Sept.* 15
Vulture's Tail	11	*Aug.* 1
Right Knee of *Ophiucus*, or *Serpentarius*	*Nov.* 16	*June* 7
Scorpion's Heart	22	*May* 5
Brightest Star in the *Eagle*	*Nov.* 25	*Aug.* 2
In the Thigh of *Pegasus*, *Scheat*	*Dec.* 11	*Sept.* 26
In the Head of *Andromeda*	25	*Oct.* 11

PROB. LII.

Given, the Latitude of the Place, and the Oblique Ascension of a Star, to find when it will rise Achronically.

This Problem is solv'd in the preceding; for inasmuch as the Point of the Ecliptic answering to the Oblique Ascension rises with it; therefore its opposite Point must be the Place of the Sun, when the Star rises Achronically: Consequently the Cosmical Rising and Setting being known, the Achronical Rising and Setting of the same Star is known also: As for Instance, if I would know the Degree of the Ecliptic the Sun is in when the *Pleiades* rise Achronically at *London*, having found that 13° 46′ of *Taurus* rises with them, therefore it tells me that *Scorpio* 13° 46′ (being the opposite Point) will set as the *Pleiades* rise; and the Sun passes that Place about the 26th Day of *October*; and that is the Day at *London* when the *Pleiades* rise Achronically. But to make it more plain, I shall give the Trigonometrical Investigation, by *Prob.* 34.

	Deg.	*Min.*	*Sec.*
Longitude of the *Pleiades* ♉	26	10	58
Latitude North	4	00	37
Declination North	23	14	00
Right Ascension	52	50	00
Ascension Difference sub.	32	22	00
Oblique Ascension past ♈	20	08	00

	Deg.	*Min.*	
As Radius	90	00	10.000000
To C. s. Ob. Asc.	20	8	9.972617
So C. t. Latitude	51	32	9.900086
To C. t. of	53	17	9.872703
Obliquity add	23	29	
As C. s. of sec. *Angle*	76	46	Co. Ar. 0.640321
To C. s. of the first	53	17	9.776598
So t. Ob. Ascen.	20	8	9.564202
To t. past ♈	43	46	9.981121

That is *Taurus* 13° 46′, and the opposite Point of the Ecliptic thereto is *Scorpio* 13° 26′; to which Point the Sun comes about the 26th Day of *October*, the Day on which the *Pleiades* rise Achronically at *London*.

Example 2. I would know the Day at *London* when *Fomahaunt* will riſe Achronically at *London?*

SOLUTION.

In Page 283. I found the Degree of the Ecliptic the Sun is in to be *Taurus* 29° 31' when the Star riſes Coſmically; therefore the Sun muſt poſſeſs *Scorpio* 29° 31' when the ſame Star riſes Achronically, and to this Place the Sun comes about the 10th of *November*.

PROB. LIII.

Given, the Latitude of a Place, and the Oblique Deſcenſion of a Star, to find when it will ſet Achronically.

The ſame Degree of the Ecliptic that deſcends with the Oblique Deſcenſion of the Star, is the Place that the Sun muſt poſſeſs when the given Star ſets Achronically. Therefore, as the oppoſite Point of the Ecliptic that the Sun poſſeſſes when a Star riſes Coſmically, makes its Achronical Riſing; ſo the Sun muſt be in the oppoſite Point of the Ecliptic when a Star ſets Coſmically, to cauſe the Star's Achronical ſetting.

Example. At *London* the Day of the Achronical ſetting of the *Pleiades* is required.

This is ſolved in *Page* 286; for there I have found that the Sun muſt be in ♏ 29° 16' to cauſe their Coſmical ſetting; therefore the oppoſite Degree ♉ 29° 16' muſt be the Place of the Sun to cauſe their ſetting Achronically; and to that Place of the Ecliptic the Sun comes the 10th Day of *May*. Hence, the *Pleiades* then ſet Achronically at *London*. More Examples in things ſo plain were needleſs; becauſe the Work of theſe two Problems, is performed in the Coſmical Riſing and Setting.

A TABLE of 42 Fixed Stars, with the Days when they rise and set Achronically at London.

STARS Names.	Achron. Rising	Achron. Setting.
First in *Pegasus*'s Wing. *Marchab*	*July* 6	*March* 11
Right Shoulder in *Aquarius*	13	*Feb.* 13
Extream Star in the Wing of *Pegasus*	*August* 5	*March* 22
Last in the *Goat*'s Tail	13	*Jan.* 27
Bright Star in the *Ram*'s Head	*Sept.* 7	*April* 21
That in the former Horn, called first * ♈	12	16
In the Tail of the *Whale*	*Octob.* 16	*March* 2
The Brighest of the *Pleiades*	26	*May* 10
In the *Whale*'s Mouth, *Mencar*	*Nov.* 19	*April* 12
North Horn of the *Bull*, foot of *Auriga*	15	*May* 9
Fomahaunt	10	*Jan.* 20
North Eye of the *Bull*	21	*May* 12
In the Belly of the *Whale*	24	*March* 10
South Eye of the *Bull*, *Aldebaran*	29	*May* 12
South Horn of the *Bull*	*Decem.* 6	30
Castor	*Dec.* 10	*Aug.* 6
Pollux	21	*July* 23
Middle Star in *Orion*'s Belt	30	*May* 5
Lesser Dog, *Procyon*	*Jan.* 14	*June* 6
In the *Hare*'s Thigh	18	*April* 15
In the *Great Dog*'s Mouth, *Syrius*	26	*May* 3
Lyon's Heart	*Feb.* 4	*Aug.* 18
Lyon's Back	5	*Octob.* 19
Hydra's Heart	15	*June* 17
In the Tail of the *Lyon* *Deneb.*	18	*Octob.* 18
Vindemiatrix	*March* 7	*Nov.* 9
Arcturus	12	*Dec.* 11
Virgin's Girdle	16	*Octob.* 22
Bight Star of the *Crown*	17	*Jan.* 6
Virgin's Spike	*April* 1	*Sept.* 30
Right Shoulder of *Hercules*	3	*Jan.* 9
Left Shoulder of *Hercules*	9	*Jan.* 21
Head of *Hercules*	19	*Feb.* 6
Swan's Bill	27	16
Right Shoulder of *Ophiucus*, *Serpentarius*	*May.* 3	*Jan.* 5
Lower Wing of the *Swan*	4	*March* 5
Vulture's Tail	9	*Jan.* 28
Right Knee of *Ophiucus*	10	*Dec.* 7
Scorpion's Heart	22	*Novem.* 6
Brightest Star in the *Eagle*	25	*Jan* 29
In the Thigh of *Pegasus*, *Scheat*	*June* 11	*March* 23
In the Head of *Andromeda*	26	*Decem.* 25

From

From the four laſt Problems it is manifeſt, that from the times of the Stars Coſmical Setting, to the times of their Achronical Riſing, they are viſible above the Horizon, from the time of their Riſing, to the time of their Setting, in north Latitudes, if the Stars have ſouth Declination.

And on the contrary, from the time of their Achronical Setting, to the time of their Coſmical Riſing, they are altogether inviſible, and never appear above the Horizon from the ſetting of the Sun, to his Riſing.

As for Inſtance; *Fomahaunt* ſets Coſmically on *July* the 24th, and riſes Achronically the 10th of *November*; all which time (being 109 Days) this Star riſes after Sun-ſetting, and ſets before Sun-riſing; conſequently viſible from the time of its Riſing, to the time of its Setting. But from *Janurary* 20, the time of its Achronical Setting, to *May* 10, the time of its Coſmical Riſing, it never appears in our Hemiſphere, but when the Sun is there, and therefore inviſible.

2. And from the time of its Coſmical Riſing *May* 10, to the time of its Achronical Setting *January* 20, it conſtantly appears above the Horizon at ſome part of the Night or other.

But if the Stars have north Declination, (as ſuppoſe the *Pleiades*) they are viſible from the time of their Achronical Riſing *October* 26, to the time of their Coſmical Riſing *April* 23, or till they approach ſo near the Sun as to become Combuſt, which ſhall be the Buſineſs of the next Problem.

PROB. LIV.

Given, the Latitude of the Place, and the Depreſſion of a Star below the Horizon, and the Time of its Coſmical Riſing, to find the Time of its Heliacal Riſing.

It is known by Obſervation, that the ſmalleſt fixed Stars are not viſible till the Hemiſphere is wholly free from the Sun's Rays; that is till after the end of the Evening, and before the beginning of the Morning-twilight, which is, when the Sun is 18 *degr.* below the Horizon; and that Stars of ſeveral Magnitudes may be ſeen when the Sun is depreſſed below the Horizon, as is here ſet down.

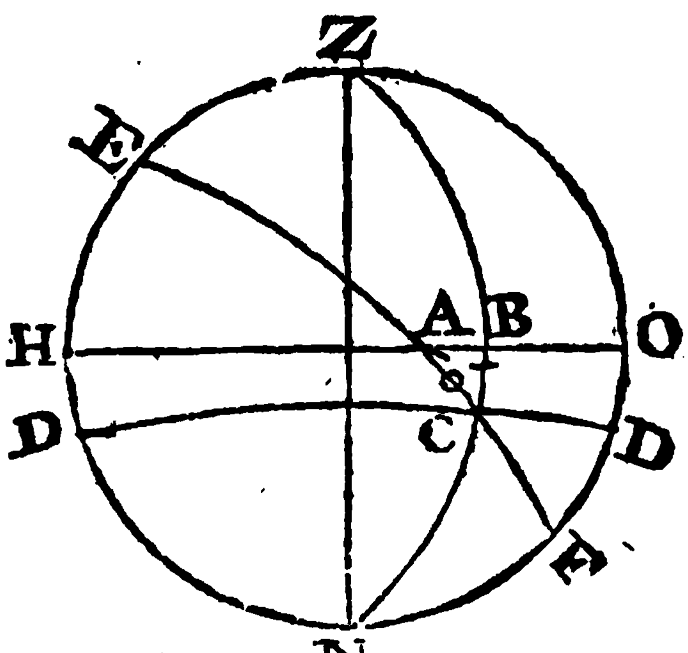
Degrees

			Degrees.	
Stars of the	1	Magnitude, may be seen when the Sun is	12	below the Horizon.
	2		13	
	3		14	
	4		15	
	5		16	
	6		17	

Example. Let the time of the Heliacal Rising of the *Pleiades* be required at *London?*

You must first by *Problem* 32, find the Altitude of the Nonagesime Degree in the given Latitude to the time of the Cosmical Rising of the Star, and the Steps of the Calculation you must observe as is here set down.

	Deg.	*Min.*	
Latitude of the given Place	51	32	N.
Pleiades rise Cosmically *April*	23		
Sun rises that Morning at	4	35	20ll
Sun's Place then ♉	13	46	found in Page 284
Sun's Right Ascension	41	18	
Time from Noon	248	50	
Sum R. A. *M. Cæli*	290	8	
Complement short of ♈	69	52	
Medium Cæli is ♑	18	35	
Meridian Angle	82	7	
Decl. Cul. Point South	22	11	
Compl. Latitude	38	28	
Altitude Mid-heaven	16	17	
Altitude Nonag. Degr.	18	3	



The Requisites above being found, I shall now explain what is required in the adjacent Figure, in which, Z H N O represent the Meridian of the Place, H O is the Horizon, E A F the Ecliptic, Z B N, a Vertical Circle, D C D the Parallel of Depression of the *Pleiades* 14 *degr.* when they become visible, after their Conjunction with the Sun, intersecting the Vertical Circle and Ecliptic at C: Now in

the

the Right-angled ſpherical Triangle A B C, right angled at B, there are given, B C the Stars Depreſſion 14 *degr.* and the Angle B A C = *Angle* H A E, the Altitude of the Nonageſime Degree, or Angle that the Ecliptic makes with the Horizon, to find A C, the Diſtance in the Ecliptic, between the Coſmical Point at A, and the Heliacal Point at C.

ANALOGY.

	Deg.	Min.	
As S. *Angle* B A C Alt. Nonag.	18	3—	9.491147
To S. B. C. the Depreſſion	14	00—	9.383675
So Radius;	90	00—	10.000000
To S. of the Arch A C	51	20—	9.892528

Which added to the Place of the Sun *Taurus* 13° 46′, at the time of the Coſmical Riſing, gives *Cancer* 5° 6′ for the Place of the Sun at the time of the Heliacal Riſing: To this place of the Ecliptic the Sun comes the 16th Day of *June*, on which Day the *Pleiades*, will begin to appear after their Conjunction with the Sun, and will be ſeen in the Morning before the Sun riſes.

PROB. LV.

Given, the Latitude of the Place, and the Depreſſion of a Star below the Horizon, and the time of the Achronical ſetting, to find the time of its Heliacal ſetting.

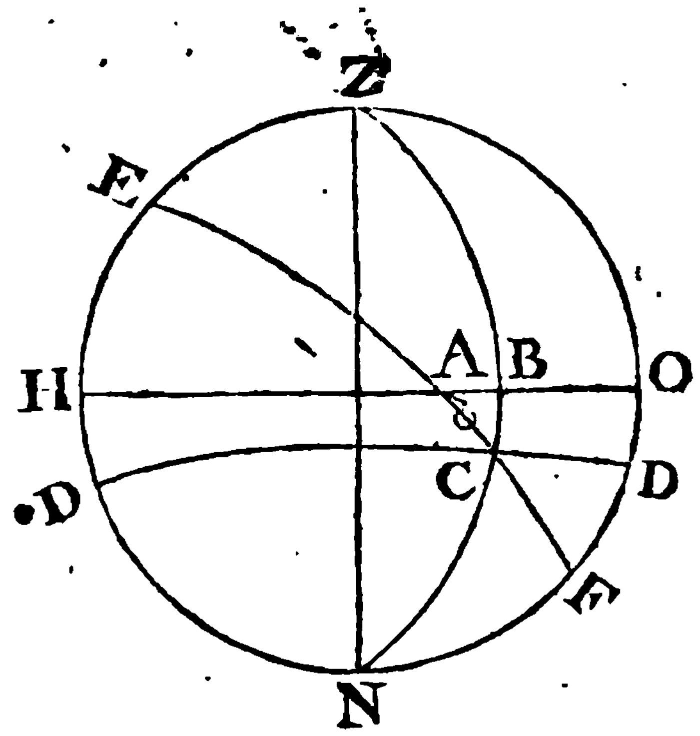
Example. Let the time of the Heliacal ſetting of the *Pleiades* be required at *London.*

The time of the Achronical ſetting is *May* 10.

	Hou.	Min.	Sec.	
Sun ſets that Evening at	7	50	20	
Sun's Place then	♉	29	16	found in Page 213
Sun's Right Aſcenſion		57	52	
Time from Noon add		117	35	
Right Aſcenſion *M. Cœli*		175	27	
Complement ſhort of ♎		4	33	
Medium Cœli in Ecliptic		♍ 25	2	
Meridian Angle		66	36	
Decl. Cul. Point North		1	58	
Complement Latitude add		38	28	
Altitude Mid-heaven		40	26	
Altitude Nonageſime Degree		45	41	

Now

Now in the adjacent Figure, Z H N O represents the Meridian of *London*, Z N the prime Vertical, H O the Horizon, E A F the Ecliptic, making an Angle with the Horizon of 45 *Deg.* 41 *Min.* D C D is the Parallel of Depression of the *Pleiades* at the time of their setting Heliacally 14°. Therefore in the right angled spherical Triangle A B C, there are given B C 14°, and the Angle B A C 45° 41′, to find the Arch A C, the Distance between the Achronical Point and the Heliacal Point.



ANALOGY.

	Deg.	Min.	
As S. *Angle* B A C, Alt. Nonag.	45	41—	9.854603
To S. B C the Depression	14	00—	9.383675
So Radius ;	90	00—	10.000000
To S. of the Arch A C	19	45—	9.529072

This 19° 45′ subtracted from the Place of the Sun *Taurus* 29° 16′ at the time of the Achronical setting, leaves *Taurus* 9° 31′, for the Place of the Sun at the time of the Heliacal setting of the *Pleiades*; and to this Place of the Ecliptic the Sun comes the 20th of *April*, which is the last Day of their appearing until the Day of their Heliacal Rising, *June* 16: So that from *April* 20, to *June* 16, the *Pleiades* cannot be seen; but all the other part of the Year they may by those who inhabit the north Parallel of 51° 32′. The same Method is to be observed in Calculating the times of the Heliacal rising and setting of any other Fixed Star: But for the Planets you must observe the Depression of the Sun, when they rise and set Heliacally, as is here set down.

Deg.

	Deg.	
♄	11	
♃	10	
♂	11	
♀	5	may be ſeen in the Day.
☿	10	was ſeen in the Day, *April* 22, 1715.
☽	5	may be ſeen in the Day.

The Knowledge of the Poetical Riſings and Settings of the Stars were of great Eſteem among the Ancients, and were very uſeful to them in adjuſting the Times ſet apart for their Religious and Civil Uſes; but now they ſerve no other end to us, than to inform us of the Ttime when we may look out for a Star or Planet, to make our Obſervations upon it as Occaſion ſhall require.

PROB. LVI.

Given, the Latitude of the Place, with the Day of the Month, and the Planet's Place at the Time it's on the Meridian, to find the Time it will be in the Nonageſime Degree.

Rule. If it is the Sun, add three Signs to its Place at Noon; but if any other Planet, add three Signs to its Place at the Time it is South; then with the Place of the Sun at Noon, or with the Place of the other Planet at the Time of its Southing, enter the Table, ſhewing when the Sun, Moon, or Star, will be in the Nonageſime Degree, *Page* 82, &c. under *R. A.* and in the next Column on the left Hand, under Time, is the Right Aſcenſion in Hours and Minutes; which write out, and reſerve. Then with the Place of the Planet, and the Sum of three Signs, enter the ſame Table in the Column under *O A*, and againſt it on the left Hand, under Time, is the Hour and Minutes anſwering, which write out alſo: Then if it is the Sun, the Difference between theſe two Quantities of Time thus taken out of the Table is the Time that the Sun will be in the Nonageſime Degree on the Day propoſed.

But if it be a Planet or Star, then this Difference of Hours and Minutes added to the Time of its Southing will give you the Time that Day or Night that it will be in the Nonagesime Degree.

Note, Always subtract the right Ascension of the Planet, from the oblique Ascension; but if Subtraction cannot be made, borrow 24 Hours to the oblique Ascension, as you see done in the following Examples.

Example. *Anno* 1727, *July* 5, at *London*, I would know the Time that the Sun will be in the Nonagesime Degree?

OPERATION.

		Deg.	*Min.*		*Ho.*	*Min.*
Sun's Place at Noon is	♋	23	15	gives R. A.	7	40
Add	3	00	00			
Sum	6	23	15	gives O. A.	8	12
Difference in the Time past Noon					0	32 the Sun is in the Nonagesime Degree.

Example 2. *September* 8, What time is the Sun in the Nonagesime Degree?

OPERATION.

		Deg.	*Min.*		*Ho.*	*Min.*
Sun's Place at Noon is	♍	25	56	gives R. A.	11	45
Add	3	00	00			
Sum	8	25	56	gives O. A.	13	55
Difference in Time past Noon					2	10 the Sun is in the Nonagesime Degree at *London*.

Example 3. *Anno* 1727, *July* 15, What time will the Moon be in the Nonagesime Degree at *London*?

OPE-

OPERATION.

		Ho.	Min.		Ho.	Min.	
Moon South at		6	47	P.M.			
Her Longitude then	7	21	10	gives R. A.	15	15	ſub.
Add	3	00	00				
Sum	10	21	10	gives O. A.	16	52	from
Difference in time		1	37				
Southing add		6	47				
☽ in Nonageſime		8	24	P. M.			

Example 4. *Anno* 1727, *October* 18, I would know the Time the Moon will be in the Nonageſime Degree.

OPERATION.

		Ho.	Min.		Ho.	Min.	
Moon South at		11	53	P. M.			
Longitude then ♉		5	34	gives R. A.	2	13	ſub.
Add	3	00	00				
Sum	4	5	34	gives O. A.	0	50	from
Remain					22	37	
Time of Southing add					11	53	
Moon in the Nonageſime Degree					10	30	Night.

Example 5. I would know what Time the *Lyon's* Heart will be in the Nonageſime Degree the 1ſt Day of *March* in this Age.

		Ho.	Min.		Ho.	Min.	
South at		10	22				
Longitude *Cor.* ♌		26	2	gives R. A.	9	53	ſub.
Add	3	0	0				
Sum	7	26	2	gives O. A.	11	20	from
Remains					1	27	
Time of Southing add					10	22	
The Star is in the Nonageſime Degree at					11	49	at Night.

Example 6. What Time will the Star *Syrius* be in the Nonagesime Degree, *February* 1, in this Age?

		Ho.	Min.		Ho.	Min.	
Syrius South at		8	51				
Longit.	3	10	21	gives R.A.	6	45	sub.
Add	3	0	0				
Sum	6	10	21	gives O.A.	7	0	from
Remains					0	15	
Time of Southing add					8	51	
Syrius is in the Nonag. Degree					9	6	at Night at *London.*

PROB. LVII.

Of the General Use of Logarithms; shewing how to find the Logarithm of a whole Number consisting of 5, 6, or 7 Places, &c. or of a Mixt, or of a Decimal Fraction.

The Tables of Logarithms of absolute Numbers we find Printed in most Books of the Mathematics; and they perform that by Addition and Subtraction, which Numbers do by Multiplication and Division: But because the common Tables run no further than 10000, and in Astronomy having frequent occasion for a Logarithm to 5, 6, or 7 Places, I shall make it my Business in this Problem to explain what is needful to be understood in these Logarithms.

Every Logarithm is noted with its proper Index, or Characteristic; and these *Indices* are separated from the rest of the Logarithm, to the Left-hand by a Dot (.); as appears here below.

The

The Characteristic of all Numbers between

1	and	10	is	0
10	and	100		1
100	and	1000		2
1000	and	10000		3
10000	and	100000		4
100000	and	1000000		5
1000000	and	10000000		6
10000000	and	100000000		7
100000000	and	1000000000		8
1000000000	and	10000000000		9

From hence it is evident, that the Characteristic is always less by one, than the Number of Places of its absolute Number unto which it doth belong. And the Logarithm of the absolute number Unity with ten Cyphers annexed is as follows.

Numbers.	Logarithms.
1	0.0000000
10	1.0000000
100	2.0000000
1000	3.0000000
10000	4.0000000
100000	5.0000000
1000000	6.0000000
10000000	7.0000000
100000000	8.0000000
1000000000	9.0000000

And here also, is to be Noted, that the Logarithm of 2, of 20, of 200, of 2000, &c. is the same, having regard to the Characteristic, as in this Table.

Numbers.

Numbers.	Logarithms.
2	0.3010300
20	1.3010300
200	2.3010300
2000	3.3010300
20000	4.3010300
200000	5.3010300
7	0.8450980
70	1.8450980
700	2.8450980
7000	3.8450980
70000	4.8450980
700000	5.8450980
7000000	6.8450980
70000000	7.8450980

The like of any other Numbers.

In the common Tables, all Numbers under 100, have their Logarithms anſwering; but obſerve to prefix the proper Characteriſtic 1, thereto.

2. From 100 to 1000 in the Column under 0, is the Logarithm anſwering.

3. But if you want any Number from 1000 to 10000, then find the three firſt Figures in the firſt Column under the Number, and the Figure that ſtands in the Place of Units at the top of the Table, and in the Angle, or Place of meeting, is the Logarithm ſought, being mindful to put the proper Characteriſtic 3. So the Logarithm of 1681, you will find to be 3.2255677. In like manner the Logarithm.

Numbers.

	Numbers.		Logarithm.
	4567.		3.6596310
	456.7		2.6596310
	45.67		1.6596310
	4.567		0.6596310
	.4567		$\bar{1}$.6596310
	.04567		$\bar{2}$.6596310
of	.004567	is	$\bar{3}$.6596310
	.09876		$\bar{2}$.9945811
	.9876		$\bar{1}$.9945811
	9.876		0.9945811
	98.76		1.9945811
	987.6		2.9945811
	9876.		3.9945811

By this it appears how the Logarithm of a whole Number, a Mixt, or Decimal Fraction is found, only by changing the Characteristic; or those with this Mark — on the top of the Figure, shew they are less than Unity, or deficient Logarithms.

1. *To find the Logarithm of a Vulgar Fraction.*

RULE. Subtract the Logarithm of the Numerator, from the Logarithm of the Denominator, taken simply as a whole Number, the Remainder shall be the Logarithm of the given Fraction.

Example. Let the Logarithm of $\frac{3}{4}$ be required?

Logar. of	4	is	0.6020600
	3		0.4771213
Logar. of $\frac{3}{4}$ is			0.1249387

So you will find the Logarithm of $\frac{1}{2}$ to be 0.3010300, and of $\frac{1}{4}$ to be -0.0602060o, which are the Logarithm of 2 and 4, only signified by the Sign *Minus* —, before them, to shew they are Fractions.

2. *To find the Logarithm of a Vulgar Mixt Number.*

RULE. Reduce the given Mixt Number into an improper Fraction, and ſubtract the Logarithm of the Denominator, taken as a whole Number; the Remainder is the Logarithm ſought.

Example. What's the Logarithm of $40\frac{4}{5}$?
Being Reduced, is this improper Fraction $\frac{204}{5}$

Logar. of	204	is	2.3096302
	5		0.6989700
Logar. of $40\frac{4}{5}$ is			—1.6106602

3. *To find the Logarithm of a Decimal Fraction.*

RULE. To the given Decimal, put its proper Denominator; then (as in the Vulgar) ſubtract the Logarithm of the Numerator, from the Logarithm of the Denominator, and the Remainder is the Logarithm of the Decimal ſought.

Example. What's the Logarithm of .25? With its Denomination it will ſtand thus $\frac{25}{100}$:

Logar. of	100	is	2.0000000
	25		1.3979400

Logar. of .25 is —0.6020600 the ſame with $\frac{1}{4}$ of the Vulgar Fraction found above.

So likewiſe you will find the Logarithm of .5 to be —0.3010300, and of .75 to be —0.1249387.

Note, That the Logarithm of a Fraction is always defective; for the Logarithm of 1 being 0.0000000, the Logarithm of $\frac{3}{4}$ *&c.* which is leſs than 1, muſt needs be defective; and by how much a Fraction approaches nearer to 1, by ſo much leſs is the Quantity of its Logarithm; as in the Logarithm of the Fractions above, you ſee that the Logarithm of $\frac{3}{4}$ is leſs than the Logarithm of $\frac{1}{2}$, and the Logarithm of $\frac{1}{2}$ is leſs than the Logarithm of $\frac{1}{4}$, *&c.*

Or,

Or, to find the Logarithm of a Decimal Fraction another Way.

RULE. Find the Logarithm of the given Decimal (without the Characteristic) as if it were a Whole Number; that done, take the Complement Arithmetical of that Logarithm, and place before it, its proper Characteristic, which must consist of so many Units as there are Cyphers before the Decimal Fraction, and that is the Logarithm sought.

Example. What's the Logarithm of this Decimal .75?

The Logarithm of 75 as whole is	1.8750613
Subtract it from	1.0000000
Logarithm of .75 is	0.1249387

4. *How to find the Logarithm of a Decimal Mixt Number.*

RULE. Seek the Logarithm of the Number given, as if it were whole, without the Characteristic, and place before it the proper Characteristic belonging to the whole Part thereof, and that shall be the Logarithm of the given mixt Number.

Example. What's the Logarithm of this Mixt Number 40.8?

The Logarithm of 408 taken as a whole Number is .6106602; before which prefix 1. the proper Characteristic to the whole Number 40, gives for the Logarithm of 40.8—1.6106602. After the same manner will you find the Logarithm of this Mixt Decimal 9.876 to be 0.9945811.

5. *To find the Logarithm of any Number consisting of 5 Places.*

For this purpose Sir *Jonas Moor* in his *Math. Comp.* has a Table of proportional Parts, with the Difference of each Logarithm, whose use is this: Suppose the Logarithm of 35786 were required; seek the Logarithm of the four first Figures towards the Left, *viz.* 3578 which is 3.553640 and the common Difference is 121; with this Difference enter the Tables of Parts proportional (in the fore-cited Book) in the Column under *Dif.* and then Lineally against that Number, and under 6 (the Figure

in the Unit's Place of the given Number 35786) you will find 72, the proportional Part; this being add to the Logarithm of 3578, *viz.* 3.553640, makes 4.553712.

But because these proportional Parts are not always Printed with the Tables of Logarithms, and consequently do not fall into the Hands of every Buyer of Mathematical Books, therefore for this reason I shall shew how to find the Logarithm of an absolute Number consisting of 5, 6, or 7 Places, without the Help of those Tables of proportional Parts.

Example. Let the Logarithm of 35786 as before be required?

Taking away the 6 from the Unit's Place, the Logarithm

of	3578 is	3.5536403
and of	3579 is	3.5537617
Difference		1214
Multiply by		6
Product		728.4
Log. of 3578 add.		.5536403
Log. of 35786-		4.5537131

Note, Ever mind to cut off from the Product so many Figures to the right Hand as you multiply the common Difference by.

6. *To find the Logarithm of any Number consisting of 6 Places.*

RULE. Take the Logarithm out of the Canon to four Places to the Left hand of the Number; and also the next greater Logarithm; and take the Difference of these two Logarithms, and multiply it by the two Figures that were taken away from the Right-hand of the Number; from the Product cut off two Figures to the Right-hand, and add the other Part of the Product to the Logarithm of the four Figures first taken out of the Canon; that Sum is the Logarithm sought.

Example. Let the Logarithm of 101265 be sought?

OPE-

OPERATION.

Logar. of	1012 is 3.0051805
Logar. of	1013 is 3.0056094
Difference	4289
Multiply by	65
	21445
	25734
Product	2787.85
Logar. of 1012 add	3.0051805
Logar. of 101265 is	5.0054593

Ever remember to prefix its proper Characteristic, which here is 5, because the given Number consisted of 6 Places.

7. *To find the Logarithm of any Number consisting of 7 Places.*

Example. Let it be required to find the Logarithm of 1012659?

OPERATION.

Logar. of. { 1012 is	3.0051805
1013 is	3.0056094
Difference	4289
Multiply by	659
	38601
	41445
	25734
Product add	3026.451
To Log. of 1012.	.0051805
Answer	6.0054831 is the Logarithm of 1012659 was required.

And likewise you will find the Logarithm of 1367631 to be 6.1359699.

Now to prove that 6.1359699 is the true Logarithm of 1367631, take ⅓ of 6.1359699, and it is 2.0453233, and the Cube Root of 1367631 is 111. This done, I look into the Canon, or Table of Logarithms, and I find that 2.0453233 is the Logarithm of 111.

Which proves that 6.1359699 is the true Logarithm of 1367631. *Note*, That taking $\frac{1}{3}$ of a Logarithm extracts the Cube Root of its Number; and take $\frac{1}{2}$ of any Logarithm and you will have the Square Root of its Number.

More Examples for Practice.

What's the Logarithm of 1046078?

OPERATION.

Difference	415
Part of the given Number	.078
	3320
	2905
	32 | 370
	019532 |
Answer	6.019564

What's the Logarithm of 110101?

Difference	395
Part of the given Number	.01
	3 | 95
	041787 |
Answer	5.041790

What's

What's the Logarithm of 55050.5?

Difference	79
Part of the given Number	.5
	39.5
	740757
Answer	4.740796

What's the Logarithm of 31587.5?

Difference	138
Part of the given Number	7.5
	690
	966
	103|50
	.499412|
Answer	4.469515

PROB. LVIII.

A Logarithm being given, to find the Number thereunto belonging.

If the Characteristic of a Logarithm be under 4, then its Number is under 10000, and is easily found in the Tables of Logarithms: But if the Characteristic be 4, 5, 6, 7, *&c.* then the Number will exceed the Verge of the Tables; and observe this Rule: By what has been said in *Prob.* 57, you may see, that when the Characteristic is 4, that then the Number will consist of 5 Places; make the Characteristic 3, and look in the Tables for the given Logarithm, or the nearest thereunto, and take the Difference between the given Logarithm, and the nearest in the Tables: Also take the Difference between the greater and lesser Logarithm in the Tables, and say,

As the whole Difference of the two Logarithms in the Table, which is greater and lesser than your given Logarithm,

Is to the Difference between the next lesser Logarithm found in the Table, and your Logarithm given;

So is 10,

To the Figure that is to supply the Unit's Place of the Number required.

But if the Characteristic be 5,

Then so is 100,

To the two Figures that are to supply the Places of the Units and Tens in the Number required.

But if the Characteristic be 6, then so is 1000,

To the three Figures, that are to supply the Units, Tens, and Hundred Places of the Number required.

Example. Let the given Logarithm be 4.5537131, and its absolute Number required?

OPERATION.

By Changing its Index to 3, it will then be ———	3.5537131
Nearest less in the Tables is 3578 ——— ———	3.5536403
Difference ———	728

Logarithm of	3578	is	3.5536403
	3579	is	3.5537617
Difference	—— ——		1214

Now say,

As 1214 : 728 : : 10 : 6, which put in the Unit's Place of 3578 it makes 35786 for the Number sought.

Example 2. Let the Logarithm be 5.0054592; I demand the Number answering thereunto.

OPERATION.

By changing the Characteristic to 3, the nearest Number in the Table is 1012.

Logarithm of	1012	is	3.0051805
	1013	is	3.0056094
Difference	———		4289

Given Logarithm is ——— ——— ——— ———	3.0054592
Logarithm of 1012 is ——— ——— ——— ———	3.0051805
Difference ——— ——— ——— ——— ——— ———	2787

Now

Now say,

As 4289 : 2787 : : 100 : 65, which put in the Units and Tens Places of the Number 1012, it makes it 101265, which is the Number anſwering the given Logarithm.

Example 3. Let the Logarithm given be 6.0054631, and the Number required?

OPERATION.

By changing the Index to 3, the Number in the Table anſwering the neareſt leſs, is 1012.

Given Logarithm is	3.0054631
Logar. of 1012 is	3.0051805
Difference	2826

Logar. of	1012 is	3.0051805
	1013 is	3.0056994
Difference		4289

Now say,

As 4289 : 2826 :: 1000 : 659 which put to the Right-hand of the Number 1012, makes it 1012659, which is the Number anſwering to the given Logarithm.

If a given Logarithm be found in the Tables without any Remainder, then there muſt be a Cypher prefixed to the Right-hand of the abſolute Number. And if the Characteriſtic be 4 and the Logarithm 4.4877039 its Number muſt be 30740.

And the Logarithm of 43200, or the like, with Cyphers in the Unit's, &c. Place, is the ſame with 432 only changing the Characteriſtic thus,

432	Logar.	2. 6354837
4320	Logar.	3. 6354837
43200	Logar.	4. 6354837

As in *Prob.* 57.

PROB.

PROB. LIX.

Shewing the Uses of the Tables, in the Appendix to the Doctrine of the Sphere.

The first Table gives you by Inspection the Golden Number and Epacts, in both Accounts, for any Year of our Lord from 1700, to 1799, inclusive.

To find them Arithmetically.

For the Golden Number, add 1 to the present Year, and divide the Sum by 19; the Remainder is the Golden Number, and the Quotient is the Revolutions that the Sun and Moon have made since the Birth of Christ.

For the *English* Epact, multiply the Golden Number by 11, and divide the Product by 30; what remains, is the Epact.

For the *Roman* Epact, subtract 11 from the *English* Epact (until the Year 1800) and the Remainder is the *Roman* Epact.

2. The second Table gives you the Dominical Letters in both Accounts till the Year 1800.

To find them Arithmetically.

For the *English Sunday-Letter*, divide the Year, its 4th Part, and 4 by 7; the Remainder subtract from 7, gives you the Number of the Letter, as is here set down.

1.	2.	3.	4.	5.	6.	7.
A.	B.	C.	D.	E.	F.	G.

For the *Roman* Letter, divide the Year, and its 4th Part by 7, the Remainder subtract from 7, gives you the Number of the *Roman* Letter reckoned as above. Also by the first Part of the Work you will discover whether it be Leap-year or what Year past; for if 1 remain when you divide the Year by 4, then 'tis the first past Leap-year; if 2 remains, 'tis the 2d past; if 3 remain, 'tis the 3d past; but if nothing remain, 'tis Leap-year.

3. The next Table is a perpetual Table of the Number of Direction, whose use is to find out the Moveable Fasts and *Westminster-Terms* Yearly. How to find it Arithmetically I have shewed in the *Definitions*, under the Words *Number of Direction*.

4. Enter the 4th, 5th, and 6th Tables with the Number of Direction in the first Column on the Left-hand for the given Year, and right against it you have all the Moveable Feasts and Terms for the said Year, in the *English* Account.

In

In Leap-Year, obſerve that what falls in *January* or *February*, will gives thoſe Days one too little; ſo that you may either take two Number of Directions, anſwering to both Dominical Letters, or elſe add one Day more to what falls in *January* and *February*.

ARITHMETICALLY.

Seek the Epact for the Year propoſed; and if it is leſs than 28, or 29, ſubtract it from 47; but if it be 28 or 29, ſubtract it from 77, the Remainder is the Day of the Month in *March* or *April*, of *Eaſter* Limit for that Year; which if it be leſs than 31, look in the Month of *March*, and count on from that Day or Limit, till you come to the *Sunday-Letter* for that Year, for that is *Eaſter-day*. But if the Limit exceed 31, ſubtract 31 from it, and count in *April* from the Day or Limit, until your Reckoning end at the Dominical Letter for the given Year, and that gives you *Eaſter-day* in *April*. Or having the Dominical Letter for any given Year, number it as above ſet down, and add 4 to it always: This Sum take from the *Limit*, and what remains, you muſt ſubtract from the neareſt Sum of Sevens, that Remainder is *Eaſter-day* in *March* if leſs than 32, or in *April* if more.

Example. What Day doth *Eaſter* fall on in the Year 1740?

From	47	Letter E =	5
Sub. Epact	12	+	4
Remains	35		9
Sum Letter and 4 =	9		
Rem. ſub.	26		
Neareſt Sum of Seven	28		
	2 add to Limit	35	
		2	
	Sum	37	
	March	31	
	April 6, *Eaſter-day*	6	

Secondly, In our Common-Prayer-Book we have the Prime or Golden Number in a Column to the Left-hand in every Month, whose Use at first was to find the New Moons, and *Easter-day*; but Time has worn out the first, and now made it useless; but its other Use stands good now, and will direct you to *Easter-day* in any Year in the *English* Account, if you carefully observe this Rule:

In *March* after the first C,
Look the Prime where ever it be,
The third *Sunday* after that *Easter-day* shall be;
And if the Prime on *Sunday* be,
Then reckon that for one of the three.

For the *Roman-Easter* see the following Table, which shews it by Inspection for this Century; and the Difference in Days every Year from the *English Easter*.

5. The Table shewing what Day of the Week begins any Month is very plain; for having the Dominical Letter for the given Year, find that on the Head, and guide your Eye down from it till you come right against the Month, and there is the Name of the Day of the Week that begins that Month.

6. The next Table shews you the Day of the Week any Day of the Month falls on in both Accounts; for in the first Column you have the *Julian* or *English* Months, standing against the Letter (in the first Column of Letters) that begins the Month it stands against: And in the last Column to the Right-hand are the *Gregorian* or *Roman* Months, standing against the Letter that begins the Month.

Under the Dominical Letters are the Day of the Month to 31.

Then count from the *Sunday-Letter* (in both Accounts) in the same Line with the Months, till you come to the Letter that begins the Month, and where that Reckoning ends is the Day of the Week that begins that Month.

Then suppose I would know what Day of the Week the 25th Day of *October* falls on in both Accounts 1727?

For the *English*, first, find the *Sunday* Letter A, in the first Column *October*; and because I find it stands against the *Sunday* Letter, that informs me that the 1, 8, 15, 22, and 29 Days are all *Sundays*, and that the 2, 9, 16, 23, 30, are all *Mondays*, and the 3, 10, 17, 24, 31, are all *Tuesdays* in *October*, and *January*, &c. as the Figures underneath shew. And the 4, 11, 18, 25, are all *Wednesdays*, &c.

For

For the *Roman*, their *Sunday* Letter is E, which I seek in the same Line right against *October* on the Right-hand, and call E *Sunday*, F *Monday*, G *Tuesday*, A *Wednesday*, which is the first Day of the Month: Then I go to the Figures; and because the 1st is *Wednesday*, the 8, 15, 22, 29 are *Wednesdays*, 2, 19, 16, 23, 30 are *Thursdays*, the 3, 10, 17, 24, 31 are *Fridays*, and 4, 11, 18, 25 Days *Saturdays* in *October* in the *Roman* Account. But for this purpose (in the *English* Account) I have given you Expeditious Tables in my *System of the Planets Demonstrated*.

7. The Table for the Number of Days is obvious to the meanest Capacity; for find the Moon in the first Line on the Head, and under it in the same Column in any Month is the Number of Days from any Day of the Month on the Head to the same Day of the Month in any other Months: As, from *August* 29, to *January* 29, is 153 Days; the like of any other. And this is useful in computing the mean Place of the Moon's Nodes; for knowing the Place of the North Node any one Year, (as suppose *January* 1, 1727, ☊ be in 0 S. 4°. 27′ 25″, and I would have its mean Place *October* 25 next following) I look into this Table, and find from *January* 1, to *October* 1, 273 Days; to which add 24 Days, make 297 Days from *January* 1, to *October* 25 inclusive: Then, because the mean Diurnal Motion of the Node Retrograde is $3' \, 11'' = 191'' \times 297 = 15^\circ \; 45' \; 27''$ for the mean Motion of the Node in that Time, which subtracted from the Place of the Node *January* 1, ♈ 4° 27′ 25″ leaves ♓ 18° 41′ 58″ for the mean Place of the Node *October* 25, as was required. All the other Tables in the Appendix are so obvious to the meanest Capacity, that nothing needs be said by way of Explanation.

8. For the Moon's Age, add to the Epact for the given Year the Day of the Month, and the Number of the Months, as is here set down; and if the Sum is under 20, that is the Moon's Age; but if it exceed 30, cast away 30, and the Remainder is the Age of the Moon. The Months must be numbred thus:

0	2	1	2	3	4	5	6	8
January	*February*	*March*	*April*	*May*	*June*	*July*	*August*	*September*
8	10	10						
October	*November*	*December*						

9. For the Day of the New Moon, add the Number of Months, and the Epact together, and subtract the Sum from 30; but if the Sum exceed 30, subtract it from 59, and the Remainder is the Day of the New Moon according to her middle Motion.

The Day of the Full Moon is gained by subtracting the above-mentioned Sum from 15; but when Subtraction cannot be made, borrow 30 Days, and the Remainder will give you the Day of the Full Moon according to her mean Motion.

PROB. LX.

To find the Sun's Declination.

In the second Volume you have new Tables of the Sun's Declination to every Degree and Minute of the Ecliptic, by entering with the Sign and Degree of the Sun's Place on the Head, and Minutes in the first Column of the Left-hand, in the Place of Meeting is the Sun's Declination in Degrees and Minutes: But if the Sign be at the Bottom, then take the Minutes on the Right-hand Ascending, and that gives the Declination.

Example. Let the Sun be in ♊ or ♐ 10 Degrees 40 Min. you will find the Declination 22 Degrees 5 Minutes 13 Seconds North, if ☉ be in ♊, but South if in ♐.

Next to this I have also given a Table of Declination to every Degree of North and South Latitude, of excellent Use to find the Declination of the Planets, as your own Reason with a little Practice will soon make perfect.

PROB. LXI.

Shewing the Use of Street's *Logistical Logarithms.*

These Logistical Logarithms were first Printed in *Street's Astronomia Carolina*; and run only to 60′; but I have continued them to twice that Number, *viz.* to 120′ or 2 Hours in Time. They serve expeditiously to find the proportional Part in an Astronomical Calculation. In which, the Top-line of large Figures which run from 0 to 119, may be taken as Degrees, Minutes, or Seconds, either in Time or Motion, as the

the Case requires; and the first Column of every Page may be either Minutes, Seconds, or Thirds; that is, if the Figures on the Head be taken as Degrees, then these in the first Column are Minutes; but if the other be Minutes, then these are Seconds, *&c.* And the Figures in the second Line beginning with 0, and running to 3540, are the Minutes in the Degrees that stand above them: Or they are the Seconds in those Minutes. And these are of use in finding the proportional Part of large Differences in the Logarithms of the Planet's Distances from the Sun.

To find a Logistical Logarithm to any Degrees and Minutes, look for the Degree on the Head, and the Minutes in the first Column on the Left-hand, and in the common Angle or Place of Meeting is the Logarithm sought.

As, suppose, you want the Logarithm of 20° 15′ or of 20′ 15″, you'll find it to be 4717; and the Logarithm of 24 Hours you'll find after the same manner 3979; always remembring when you work by these L. L. to reject Radius 10000. And I generally use these for finding the proportional Parts: But in my Practice I generally use a Sliding *Gunter's* Scale, which I recommend to the ingenious Student.

Example. Let the mean Anomaly of *Mars* be 2 S. 17° 25′ 38″, I demand the true Equation, and Logarithm of his Distance from the Sun at that time?

OPERATION.

	S.	°		°	′	″		
To	2	17	is Equation	10	4	00	Logar.	5.195244
	2	18		10	7	29		5.194606
Differences					3	29		636

Now for the Equation, say, by the L. L.

	′	″	LL
If one Degree or	60	00	0
Give the X	3	29	12341
What Anomaly	25	38	3693
Answ. Propor. Part	1	30	16034.

Now because the Equation is increasing, this Proportional Part 1 Minute 30 must be added to the Equation answering 2 Signs 17 Degrees, and it makes 10 Degrees 5 Minutes 30 Seconds, the true Equation to be subtracted.

For

For the Logarithm, say, by the L. L.

	′	″	
If one Degree or	60	00 LL	0
Give X	636		7528
What Anomaly	25	38	3693
Answ. Propor. Part	272		11221.

Here, because the Planet is going towards his *Perihelion*, the Logarithm of his Distance from the Sun decreases; therefore the proportional Part 272 must be subtracted from the Logarithm answering to 2 S. 17°, and there will remain 5.194972, the Logarithm of the Distance of *Mars* from the Sun.

And after the same manner you must always find the Planets Equation and Logarithm-distance from the Sun or Earth answering to their mean Anomalies, at the time when you seek their Places.

What other Varieties may fall in your way in using these Logistical Logarithms, may be known by the following Examples; by which you may see when to add, and when to subtract the Logarithms, according as they are more or less than 60 Minutes.

AH

Varieties of working by Street's *Legiſtical Logarithms.*

	Min.	Sec.			
If	60	0	LL	0	
Give	2	27		13890	add
What	57	30		185	
Anſw.	2	21		14075	

If	60	0	LL	0	
Give	2	24		13979	ſub.
What	75	9		977	
Anſw.	3	0		13002	

60	0	LL	0	
36	21		2176	ſub.
104	53		2426	from
63	34		250	

60	0	LL	0	
63	41		258	from
58	48		88	ſub.
62	24		170	

60	0	LL	0	
40	45		1680	ſub.
88	21		1680	
60	0		0	

60	0	LL	0	
70	0		670	ſub.
46	0		1154	from
53	40		484	

☉	16	2	LL	5731	ſub.
Six Digits				10000	à
	4	15		11498	
1Q	35	25		15767	

Min.	Sec.			
26	17	LL	3585	ſub.
60	00		0	
1	40		15563	from
3	48		11978	

32	8	LL	2712	from
60	00		0	
57	20		197	ſub.
107	4		2515	

34	19	LL	2426	from
60	00		0	
79	17	±3938:	1801	ſub.
138	34	5917	625	

33	19	LL	2555	add
60	0		0	
60	8		9	
108	17		2564	

88	21	LL	1680	add
60	00		0	
40	45		1680	
27	41		3360	

88	22	LL	1680	from
60	0		0	
69	17		625	ſub.
47	3		1055	

24	0	LL	3979	add
61	0		71	
10	0		7782	from
	Sum		4050	ſub.
25	24		3732	

	Min.	Sec.			
☉	16	8	LL	5704	sub.
6^s	00	0		10000	à
	10	52		7421	
4	2	27		11717	

☽	16	40	LL	5563	add
6^s	0	0		10000	à
	62	0		142	to
			Sum	5705	sub.
	22^s	19		4295	

☽	16	40	LL	5563	sub.
6^s	0	0		10000	à
	38	29		1946	
13	48	0		6383	

Or thus:

☽	14	52	LL. CA.	3941	add
6^s	0	0		10000	add
	50	14		772	add
20	16	15		4713	

24	0	LL	3979	from
48	0		969	add
31	13		2838	add
		Sum	3807	sub.
62	26		172	

Or thus:

24	0	LL	3979	add
48	0	Co. Ar.	031	add
31	12	Co. Ar.	7162	add
62	22		172	

Hour	Min.			
24	0	LL. C.A.	6021	add
14	38		6128	add
9	27		8027	add
5	46		10176	

Omit an Unit to the Left-hand

58	26	LL. C.A.	885	add
24	0	0	3979	add
9	27		2494	add
13	53		6358	

	92	42	LL	1893	add
24	0	0		3979	add
			Sum	5869	from
	82	41		1392	sub.
	21	24		4477	

Or thus:

Deg.	Min.			
92	42	LL	1890	add
24	0		3979	add
82	41	C.A.	8608	add
21	24		4477	

19	40	LL	4844	sub.
24	0		3979	add
7	3		9300	add
			13279	from
8	36		8435	

Or

AN

APPENDIX, &c.

A TABLE shewing the Golden Number and Epacts in both Accounts, to the Year 1800.

Gold. Numb.	Engl. Epact.	Rom. Epact.	Anno Domini.					
10	20	9	1700	1719	1738	1757	1776	1795
11	1	20	1701	1720	1739	1758	1777	1796
12	12	1	1702	1721	1740	1759	1778	1797
13	23	12	1703	1722	1741	1760	1779	1798
14	4	23	1704	1723	1742	1761	1780	1799
15	15	4	1705	1724	1743	1762	1781	
16	26	15	1706	1725	1744	1763	1782	
17	7	26	1707	1726	1745	1764	1783	
18	18	7	1708	1727	1746	1765	1784	
19	29	18	1709	1728	1747	1766	1785	
1	11	29	1710	1729	1748	1767	1786	
2	22	11	1711	1730	1749	1768	1787	
3	3	22	1712	1731	1750	1769	1788	
4	14	3	1713	1732	1751	1770	1789	
5	25	14	1714	1733	1752	1771	1790	
6	6	25	1715	1734	1753	1772	1791	
7	17	6	1716	1735	1754	1773	1792	
8	28	17	1717	1736	1755	1774	1793	
9	9	28	1718	1737	1756	1775	1794	

Seek the Year of our Lord, and right against it on the left Hand you have the *Roman* and *English* Epacts, with the Golden Number under their proper Titles for the Year proposed.

A Table shewing the Cycle of the Sun, and Dominical Letters in both Accounts for 100 Years.

Cycle Sun.	Letter Engl.	Letter Rom.	Anno Dom.			
1	G E	D C	1700	1728	1756	1784
2	E	B	1701	1729	1757	1785
3	D	A	1702	1730	1758	1786
4	C	G	1703	1731	1759	1787
5	B A	F E	1704	1732	1760	1788
6	G	D	1705	1733	1761	1789
7	F	C	1706	1734	1762	1790
8	E	B	1707	1735	1763	1791
9	D C	A G	1708	1736	1764	1792
10	B	F	1709	1737	1765	1793
11	A	E	1710	1738	1766	1794
12	G	D	1711	1739	1767	1795
13	F E	C B	1712	1740	1768	1796
14	D	A	1713	1741	1769	1797
15	C	G	1714	1742	1770	1798
16	B	F	1715	1743	1771	1799
17	A G	E D	1716	1744	1772	
18	F	C	1717	1745	1773	
19	E	B	1718	1746	1774	
20	D	A	1719	1747	1775	
21	C B	G F	1720	1748	1776	
22	A	E	1721	1749	1777	
23	G	D	1722	1750	1778	
24	F	C	1723	1751	1779	
25	E D	B A	1724	1752	1780	
26	C	G	1725	1753	1781	
27	B	F	1726	1754	1782	
28	A	E	1727	1755	1783	

Find the Year of our Lord, and against it on the left Hand is the Cycle of the Sun, and Sunday Letter in both Accounts.

A Table shewing the Number of Direction for ever.

Gold. No.	A	[illegible]	C	D	E	F	G
1	19	20	21	22	16	17	18
2	6	6	7	8	9	10	11
3	26	27	28	29	30	24	25
4	19	13	14	15	16	17	18
5	5	6	7	8	2	3	4
6	26	27	21	22	23	24	25
7	12	13	14	15	16	10	11
8	33	34	35	29	30	31	32
9	19	20	21	22	23	24	18
10	12	13	7	8	9	10	11
11	26	27	28	29	30	31	32
12	19	20	21	15	16	17	18
13	5	6	7	8	9	10	4
14	26	27	28	29	23	24	25
15	12	13	14	15	16	17	18
16	5	6	7	1	2	3	4
17	26	20	21	22	23	24	25
18	12	13	14	15	9	10	11
19	33	14	28	29	30	31	32

A Table to reduce the *Gulian* Year to the *Gregorian.*

	1582 October 5	
	Add	10
	1630	10
	1700	11
24 Febr.	1800	12
	1900	13
	2000 B	13
	2100	14
	2200	15
	2300	16
	2400 B	16
	2500	17
	2600	18
	2700	19
	2800 B	19
	2900	20
	3000	21
	3100	22
	3200 B	22
	3300	23
	3400	24
	3500	25

Enter this Table with Golden Number on the Left-hand, and Dominical Letter on the Head for the given Year, and in the place of Meeting is the Number of Direction for the said Year.

To find what day of the week begins *January*, in any year, A fourth part add to the Year last gone, Divide by 7, the Day rest alone, and for the other Months

	Feb.	*Mar.*	*Apr.*	*May.*	*June*	
Add	3 and	3	6	1 and	4	
	6	2	5	0	3	5
	July.	*Aug.*	*Sep.*	*Octob.*	*Nov.*	*Decemb.*

Example, what day of the week is the first of *January* 1738

Operation, 4) 1737 (434
434

7) 2171 (310

Remaine 1 or Sunday.

In Leap year, observe that what falls in *January*, or *February*, you must call the Number, of Direction one more than what you find it to be for the whole year, otherways, the Sundays after *Epiphany*, *Septuagesima*, *Quinquagesima*, and the first Day of Lent, will be one Day too little.

And by the Table in page 317, find the *Roman*, Easter; for the given year, which find in this Table, and in the same Line you have all the other Feasts for that year depending thereon.

A perpetual Table, ſhewing what Day of the Week begins any Month for ever.

Months	A	B	C	D	E	F	G
January	Sunday	Satur.	Friday	Thurſ.	Wedn.	Tueſd.	Mond.
Februar.	Wedn.	Tueſd.	Mond.	Sunday	Satur.	Friday	Thurſ.
March	Wedn.	Tueſd.	Mond.	Sunday	Satur.	Friday	Thurſ.
April	Saturd.	Friday	Thurſ.	Wedn.	Tueſd.	Mond.	Sund.
May	Mond.	Sunday	Satur.	Friday	Thurſ.	Wedn.	Tueſd.
June	Thurſ.	Wed.	Tueſd.	Mond.	Sunda	Saturd.	Friday
July	Saturd.	Friday	Thurſ.	Wedn.	Tueſd.	Mond.	Sund.
Auguſt	Tueſd.	Mon.	Sunda	Saturd.	Friday	Thurſ.	Wedn.
Septem.	Friday	Thurſ.	Wedn.	Tueſd.	Mond.	Sunda	Satur.
October	Sunday	Satur.	Friday	Thurſ.	Wedn.	Tueſd.	Mond.
Novem.	Wedn.	Tueſd.	Mond.	Sunday	Satur.	Friday	Thurſ.
Decemb.	Friday	Thurſ.	Wedn.	Tueſd.	Mond.	Sunda	Satur.

A Table to find what Day of the Week any Day of the Month falls on for ever, in both Accounts.

Julian M.	Days of the Week.							Gregor M.
Jan. October	A	B	C	D	E	F	G	April July
Fe. Mar. No.	D	E	F	G	A	B	C	Auguſt.
April July	G	A	B	C	D	E	F	Sep. Decem.
May	B	C	D	E	F	G	A	October
June	E	F	G	A	B	C	D	Feb, March No.
Auguſt	C	D	E	F	G	A	B	January May
Sep. Decem.	F	G	A	B	C	D	E	June
Days of the Months.	1	2	3	4	5	6	7	
	8	9	10	11	12	13	14	
	15	16	17	18	19	20	21	
	22	23	24	25	26	27	28	
	29	30	31					

N. B. You muſt count from the Sunday Letter (in both Accounts) in the ſame Line with the Month, till you come with the Letter that begins the Month.

A Table of the semi-diurnal Ark, to every Degree of the six first Signs of the Ecliptic Lat. *London.*

	♈		♉		♊		♋		♌		♍	
o	H	'	H	'	H	'	H	'	H	'	H	'
0	6	0	6	59	7	51	8	13	7	50	6	59
1	6	2	7	1	7	52	8	13	7	49	6	58
2	6	4	7	3	7	53	8	12	7	47	6	56
3	6	6	7	5	7	55	8	12	7	46	6	54
4	6	8	7	7	7	56	8	11	7	45	6	52
5	6	10	7	9	7	57	8	11	7	43	6	50
6	6	12	7	10	7	58	8	10	7	42	6	48
7	6	14	7	12	7	59	8	10	7	41	6	46
8	6	16	7	14	8	0	8	9	7	40	6	44
9	6	18	7	15	8	1	8	9	7	39	6	42
10	6	20	7	17	8	2	8	8	7	38	6	40
11	6	22	7	19	8	3	8	8	7	37	6	38
12	6	24	7	21	8	4	8	7	7	36	6	36
13	6	26	7	23	8	5	8	7	7	35	6	34
14	6	28	7	24	8	6	8	6	7	33	6	32
15	6	30	7	26	8	6	8	6	7	31	6	30
16	6	32	7	28	8	7	8	5	7	30	6	28
17	6	34	7	30	8	7	8	4	7	28	6	26
18	6	36	7	31	8	8	8	4	7	26	6	24
19	6	38	7	33	8	8	8	3	7	23	6	22
20	6	40	7	35	8	9	8	2	7	20	6	20
21	6	42	7	37	8	9	8	1	7	17	6	18
22	6	44	7	39	8	10	8	0	7	15	6	16
23	6	46	7	40	8	10	7	59	7	13	6	14
24	6	48	7	42	8	11	7	57	7	11	6	12
25	6	50	7	44	8	11	7	56	7	9	6	10
26	6	52	7	45	8	12	7	55	7	7	6	8
27	6	54	7	47	8	12	7	53	7	5	6	6
28	6	56	7	48	8	13	7	52	7	3	6	4
29	6	58	7	49	8	13	7	51	7	1	6	2
30	6	59	7	51	8	13	7	50	6	59	6	0

A Table of the semi-diurnal Ark, to every Degree of the last six Signs of the Ecliptic Lat. *London:*

	♎		♏		♐		♑		♒		♓	
o	H	'	H	'	H	'	H	'	H	'	H	'
0	6	0	5	1	4	10	3	47	4	10	5	1
1	5	58	4	59	4	8	3	47	4	11	5	2
2	5	56	4	57	4	7	3	48	4	13	5	4
3	5	54	4	55	4	5	3	48	4	14	5	6
4	5	52	4	53	4	4	3	49	4	15	5	8
5	5	50	4	52	4	3	4	49	4	17	5	10
6	5	48	4	50	4	2	3	50	4	18	5	12
7	5	46	4	48	4	1	3	50	4	19	5	14
8	5	44	4	46	4	0	3	51	4	20	5	16
9	5	42	4	45	3	59	3	51	4	21	5	18
10	5	40	4	43	3	58	3	52	4	22	5	20
11	5	38	4	41	3	57	3	52	4	23	5	22
12	5	36	4	39	3	56	3	53	4	24	5	24
13	5	34	4	37	3	5	3	53	4	25	5	26
14	5	32	4	36	3	54	3	54	4	27	5	28
15	5	30	4	34	3	54	3	54	4	29	5	30
16	5	28	4	32	3	53	3	55	4	30	5	32
17	5	26	4	30	3	53	3	56	4	32	5	34
18	5	24	4	29	3	52	3	56	4	34	5	36
19	5	22	4	27	3	51	3	57	4	37	5	38
20	5	20	4	25	3	51	3	58	4	40	5	40
21	5	18	4	23	3	50	3	59	4	43	5	42
22	5	16	4	21	3	50	4	0	4	45	5	44
23	5	14	4	20	3	49	4	1	4	47	5	46
24	5	12	4	18	3	49	4	3	4	49	5	48
25	5	10	4	16	3	48	4	4	4	51	5	50
26	5	8	4	15	3	48	4	5	4	53	5	52
27	5	6	4	13	3	48	4	7	4	55	5	54
28	5	4	4	12	3	47	4	8	4	57	5	56
29	5	2	4	11	3	47	4	9	4	59	5	58
30	5	1	4	10	3	47	4	10	6	11	6	0

A Table of the Latitudes, and Difference of Meridians from *London*, of some of the most eminent Cities in the World.

PLACES NAMES.	Lat. °	'	Dif. M h	'
Aberdeen	57N	6	0S	7
Amsterdam	52	29	0A	21
Archangel	64	30	2A	42
Arles in France	43	40	0A	27
Aix la Chapelle in Germany	50	48	0A	44
Barbados, middle	13	24	3S	53
Berlin	52	33	0A	54
Boston in New England	42	0	4S	45
Berwick	55	50	0S	8
Bononia	44	30	0A	47
Bedford	52	6	0S	2
Cambridge	52	17	0A	0⅓
Constantinople	41	6	2A	7
Copenhagen	55	43	0A	50
Cracovia	50	10	1A	18
Danzick	54	13	1A	16
Douglass in Man Isle	54	4	0S	18
Dublin	53	20	0S	28
Edinburg	56	7	0S	12
Elsinour	56	0	0A	50
Exeter in England	50	44	0S	14
Ferrara in Italy	44	54	0A	47
Fez in Barbary	33	10	0S	24
Fort St George	13	8	5A	24
Gibraltar	36	30	0S	25
Glascow	55	50	0S	17
Greenwich Observatory	51	28½	0A	0⅓
Hamburg	53	57	0A	41
Hanover	52	35	0A	40
Hoaignam in China	33	35	7A	56
Helvoetsluys	52	10	0A	18
Hague	52	8	0A	19
Jamaica, Middle	18	25	5S	4
Java East-end	6 S	20	7A	34
Jerusalem	32N	30	2A	22
Kelmar in Denmark	56	40	1A	6
Kebeck, or Quebeck	46	55	4S	39
Kendal in England	54	15	0S	10
Leverpool	53	22	0S	10
Lisbon	38	42	0S	37
London	51	32	0	0
Madrid	40	10	0S	13
Manchester	53	22	0S	9
Marseilles	43	20	0A	22
Moscow.	55	25	2A	38

A Table of the Latitudes, and Difference of Meridians from *London*, of some of the most eminent Cities in the World.

PLACES NAMES.	Lat. °	′	Dif. M. h	′
Naples	41 N	8	1 A	0
New York	41	40	4 S	48
Noremberg	49	29	0 A	49
North Cape	71	25	1 A	28
Ostend in Flanders	51	11	0 A	12
Oxford	51	46	0 S	5
Ozala in Japan	35	5	7 A	32
Paris	48	51	0 A	10
Petersburgh	60	4	2 A	36
Port Mahon	39	45	0 A	16
Qoaqu in Guinea	4	16	0 S	16
Revel in Finland	59	13	1 A	30
Rome	41	50	0 A	52
Roterdam	52	8	0 A	16
Scanderoon	36	30	2 A	27
St Christophers	17	30	4 S	6
Stockholm	59	30	1 A	10
Suratt in India	21	30	4 A	48
Syracusa in Sicily	37	4	1 A	1
Tameswaer in Hungary	47	30	1 A	21
Tangier, Africa	35	55	0 S	25
Trent in Germany	47	20	0 A	54
Toledo in Spain	39	54	0 S	15
Turin in Italy	44	50	0 A	29
Valentia in Spain	39	45	0 S	1
Venice in Italy	45	36	0 A	52
Vienna	48	14	1 A	1
Virginia Cape Charles	37	47	4 S	57
Uraniberg, Tycho Brahe's Observatory	55	54½	0 A	52
Warsaw in Poland	52	14	1 A	27
Waterford in Ireland	52	7	0 S	31
Wiggan in England	53	34	0 S	11
Winchester	51	3	0 S	5
Woodstock	51	53	0 S	6
Worcester	52	14	0 S	9
Yarmouth in Wight	50	41	0 S	7
York	54	0	0 S	4
Zamora in Spain	41	45	0 S	19

A TABLE of the true Time of the *Roman* Easter, with the Difference in Days from the *Julian* Account, until the Year 1800

Year	Roman Easter.	Difference.	Year	Roman Easter.	Difference.	Year	Roman Easter.	Difference.	Year	Roman Easter.	Difference.
1700	Ap. 11	0	1728	Mar. 28	35	1756	Apr. 18	7	1784	Apr. 11	0
1701	Mar. 27	35	1729	Apr. 17	0	1757	Apr. 10	0	1785	Mar. 27	35
1702	Apr. 16	0	1730	Apr. 9	0	1758	Mar. 26	35	1786	Apr. 16	7
1703	Apr. 8	0	1731	Mar. 25	35	1759	Apr. 15	7	1787	Apr. 8	0
1704	Mar. 23	35	1732	Apr. 13	7	1760	Apr. 6	0	1788	Mar. 30	28
1705	Apr. 12	7	1733	Apr. 5	0	1761	Mar. 22	35	1789	Apr. 19	0
1706	Apr. 4	0	1734	Apr. 25	0	1762	Apr. 11	7	1790	Apr. 4	0
1707	Apr. 24	0	1735	Apr. 10	7	1763	Apr. 3	0	1791	Mar. 27	28
1708	Apr. 8	7	1736	Apr. 1	35	1764	Apr. 22	0	1792	Apr. 15	0
1709	Mar. 31	35	1737	Apr. 21	0	1765	Apr. 7	7	1793	Mar. 31	35
1710	Apr. 20	0	1738	Apr. 6	7	1766	Mar. 30	35	1794	Apr. 20	0
1711	Apr. 5	7	1739	Mar. 29	35	1767	Apr. 19	0	1795	Apr. 12	0
1712	Mar. 27	35	1740	Apr. 17	0	1768	Apr. 3	7	1796	Mar. 27	35
1713	Apr. 16	0	1741	Apr. 2	7	1769	Mar. 26	35	1797	Apr. 16	0
1714	Apr. 1	7	1742	Mar. 25	35	1770	Apr. 15	0	1798	Apr. 8	0
1715	Apr. 21	7	1743	Apr. 14	0	1771	Mar. 31	7	1799	Mar. 24	35
1716	Apr. 12	0	1744	Apr. 5	0	1772	Apr. 19	7			
1717	Mar. 28	35	1745	Apr. 18	7	1773	Apr. 11	0			
1718	Apr. 17	7	1746	Apr. 10	0	1774	Apr. 3	28			
1719	Apr. 9	0	1747	Apr. 2	28	1775	Apr. 16	7			
1720	Mar. 31	28	1748	Apr. 14	7	1776	Apr. 7	7			
1721	Apr. 13	7	1749	Apr. 6	0	1777	Mar. 30	28			
1722	Apr. 5	0	1750	Mar. 29	28	1778	Apr. 19	0			
1723	Mar. 28	28	1751	Apr. 11	7	1779	Apr. 4	7			
1724	Apr. 16	0	1752	Apr. 2	7	1780	Mar. 26	35			
1725	Apr. 1	7	1753	Apr. 22	0	1781	Apr. 15	0			
1726	Apr. 21	0	1754	Apr. 14	0	1782	Apr. 7	0			
1727	Apr. 13	0	1755	Mar. 30	35	1783	Mar. 23	35			

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Sun's Declination South.

A perpetual Table of the Sun's Rising and Setting in these Places. True Time.

Sun's Declination North.		Archangel Latitude 64° 30'						Barbados Latitude 13° 24'						Sun's Declination South.	
		Sun Rises			Sun Sets.			Sun Rises.			Sun Sets.				
°	'	h	'	''	h	'	''	h	'	''	h	'	''	°	'
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	51	48	6	8	24	5	58	48	6	1	12	1	
2		5	43	12	6	16	48	5	58	8	6	1	52	2	
3		5	34	48	6	25	12	5	57	8	6	2	52	3	
4		5	26	16	6	33	44	5	56	8	6	3	52	4	
5		5	17	44	6	42	16	5	55	12	6	4	48	5	
6		5	9	4	6	50	56	5	54	16	6	5	44	6	
7		5	0	20	6	59	40	5	53	16	6	6	44	7	
8		4	51	28	7	8	32	5	52	20	6	7	40	8	
9		4	42	24	7	17	36	5	51	20	6	8	40	9	
10		4	33	12	7	26	48	5	50	20	6	9	40	10	
11		4	23	48	7	36	12	5	49	20	6	10	40	11	
12		4	14	8	7	45	52	5	48	24	6	11	36	12	
13		4	4	12	7	55	48	5	47	40	6	12	20	13	
14		3	53	56	8	6	4	5	46	24	6	13	36	14	
15		3	43	16	8	16	44	5	45	20	6	14	40	15	
16		3	32	12	8	27	48	5	44	20	6	15	40	16	
17		3	20	32	8	39	28	5	43	16	6	16	44	17	
18		3	8	35	8	51	24	5	42	12	6	17	48	18	
19		2	55	8	9	4	52	5	41	8	6	18	42	19	
20		2	41	4	9	18	56	5	40	4	6	19	56	20	
21		2	25	40	9	34	20	5	39	4	6	20	56	21	
22		2	8	24	9	51	36	5	37	56	6	22	4	22	
23		1	49	32	10	10	28	5	36	48	6	23	12	23	
23	29	1	47	28	13	22	32	5	36	16	6	23	44	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Boston New-England Lat. 42° 39′						Cambridge Latitude 52° 17′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets.				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	56	20	6	3	40	5	55	20	6	5	40	1	
2		5	52	24	6	7	36	5	49	24	6	10	36	2	
3		5	48	56	6	11	4	5	47	36	6	12	24	3	
4		5	45	12	6	14	48	5	39	16	6	20	44	3	
5		5	41	28	6	18	32	5	34	0	6	26	0	5	
6		5	37	48	6	22	12	5	28	48	6	31	12	6	
7		5	34	0	6	26	0	5	23	22	6	36	32	7	
8		5	30	16	6	29	44	5	18	8	6	41	52	8	
9		5	26	28	6	33	32	5	12	44	6	47	16	9	
10		5	22	36	6	37	24	5	8	20	6	52	40	10	
11		5	18	44	6	41	16	5	1	40	6	58	20	11	
12		5	14	48	6	42	12	4	56	12	7	3	48	12	
13		5	10	52	6	49	8	4	51	32	7	9	28	13	
14		5	6	56	6	53	4	4	44	48	7	15	12	14	
15		5	2	2	6	57	8	4	38	56	7	21	4	15	
16		4	58	44	7	1	16	4	33	0	7	27	0	16	
17		4	53	36	7	6	24	4	26	52	7	33	8	17	
18		4	50	20	7	9	40	4	20	36	7	39	24	18	
19		4	46	0	7	14	0	4	15	16	7	45	44	19	
20		4	41	40	7	18	20	4	9	12	7	50	48	20	
21		4	37	8	7	22	52	4	1	0	7	59	0	22	
22		4	32	36	7	27	24	3	54	0	8	6	0	29	
23		4	27	56	7	32	4	3	46	52	8	13	8	23	
23	29	4	25	40	7	34	20	3	43	16	8	16	44	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North		Constantinople Latitude 41° 6′						Copenhagen Latitude 55° 43′						Sun's Declination South	
		Sun Rises.			Sun Sets.			Sun Rises			Sun Sets.				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		6	2	28	5	56	32	5	54	8	6	5	32	1	
2		6	7	00	5	53	0	5	48	16	6	11	44	2	
3		6	10	28	5	49	32	5	42	24	6	17	36	3	
4		6	14	00	5	46	0	5	36	28	6	23	32	4	
5		6	17	32	5	42	28	5	30	32	6	29	28	5	
6		6	21	00	5	39	0	5	24	32	6	35	28	6	
7		6	24	4	5	35	56	5	18	32	6	41	28	7	
8		6	28	8	5	31	32	5	12	24	6	47	36	8	
9		6	31	44	5	28	16	5	6	16	6	53	54	9	
10		6	35	24	5	24	36	5	0	4	6	59	56	10	
11		6	39	4	5	20	56	4	53	44	7	6	16	11	
12		6	42	44	5	17	16	4	47	20	7	12	40	12	
13		6	46	28	5	13	32	4	40	48	7	19	20	13	
14		6	50	16	5	9	44	4	34	52	7	25	8	14	
15		6	53	4	5	7	56	4	27	24	7	32	36	15	
16		6	57	56	5	2	4	4	20	28	7	39	32	16	
17		7	1	52	4	58	8	4	13	24	7	46	36	17	
18		7	5	52	4	54	8	4	6	8	7	53	52	18	
19		7	9	56	4	50	4	3	59	40	8	1	20	19	
20		7	13	4	4	46	56	3	50	56	8	9	4	20	
21		7	18	16	4	41	44	3	42	56	8	17	4	21	
22		7	22	32	4	37	28	3	34	36	8	25	24	22	
23		7	26	56	4	33	4	3	25	56	8	34	4	23	
23	29	7	29	4	4	30	56	3	21	40	8	38	20	23	29
		Sun Sets.			Sun Rises			Sun Sets.			Sun Rises				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Cracovia Latitude 50° 10′						Dantzick Latitude 54° 13′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets.				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	55	12	6	4	48	5	54	28	6	5	32	1	
2		5	50	24	6	9	36	5	48	52	6	11	8	2	
3		5	45	36	6	14	24	5	43	20	6	16	40	3	
4		5	40	44	6	19	16	5	37	44	6	22	16	4	
5		5	35	56	6	24	4	5	32	8	6	27	52	5	
6		5	31	4	6	28	46	5	26	28	6	33	32	6	
7		5	26	8	6	33	52	5	20	44	6	39	16	7	
8		5	21	12	6	38	48	5	15	0	6	45	0	8	
9		5	16	12	6	43	48	5	9	12	6	50	48	9	
10		5	11	12	6	48	48	5	3	20	6	56	40	10	
11		5	6	4	6	53	56	4	57	24	7	2	36	11	
12		5	0	56	6	59	4	4	51	24	7	8	36	12	
13		4	55	44	7	4	16	4	45	16	7	14	44	13	
14		4	51	24	7	8	36	4	39	0	7	21	0	14	
15		4	45	4	7	14	56	4	32	44	7	27	16	15	
16		4	39	36	7	20	24	4	26	16	7	33	44	16	
17		4	34	0	7	26	0	4	19	16	7	40	24	17	
18		4	28	16	7	31	44	4	12	51	7	47	8	18	
19		4	22	28	7	37	32	4	5	52	7	54	8	19	
20		4	16	32	7	43	28	3	58	40	8	1	20	20	
21		4	10	24	7	49	36	3	51	16	8	8	44	21	
22		4	4	8	7	55	52	3	43	36	8	16	24	22	
23		3	57	36	8	2	24	3	35	44	8	24	16	23	
23	29	3	54	28	8	5	32	3	31	44	8	28	16	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

		Douglass Latitude 54° 4′						Dublin Latitude 53° 20′							
		Sun Rise.			Sun Sets.			Sun Rises.			Sun Sets.				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	54	28	6	5	32	5	54	40	6	5	20	1	
2		5	49	0	6	11	0	5	49	16	6	10	44	2	
3		5	43	24	6	16	36	5	43	56	6	16	4	3	
4		5	37	52	6	22	8	5	38	32	6	21	28	4	
5		5	32	16	6	27	44	5	33	12	6	26	48	5	
6		5	26	40	6	33	20	5	27	32	6	32	28	6	
7		5	21	0	6	39	0	5	21	48	6	38	12	7	
8		5	15	16	6	44	44	5	16	32	6	43	28	8	
9		5	9	32	6	50	28	5	10	52	6	49	8	9	
10		5	3	40	6	56	20	5	5	12	6	54	48	10	
11		4	57	48	7	2	12	5	0	28	6	59	32	11	
12		4	51	48	7	8	12	4	53	40	7	6	20	12	
13		4	45	44	7	14	16	4	47	20	7	12	40	13	
14		4	39	32	7	20	28	4	41	16	7	18	44	14	
15		4	33	12	7	26	48	4	35	36	7	24	24	15	
16		4	26	48	7	33	12	4	29	8	7	30	52	16	
17		4	20	12	7	39	48	4	22	52	7	37	8	17	
18		4	13	28	7	46	32	4	16	28	7	43	32	18	
19		4	6	32	7	53	28	4	9	12	7	50	48	19	
20		3	59	28	8	0	32	4	2	56	7	57	4	20	
21		3	52	4	8	7	56	3	56	12	8	3	48	21	
22		3	44	28	8	15	32	3	50	4	8	9	56	22	
23		3	36	36	8	23	24	3	43	32	8	16	28	23	
23	29	3	32	40	8	27	20	3	37	12	8	22	48	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

Sun's Declination North.

Sun's Declination South.

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

	Edenburgh Latitude 56° 7′						Fort St George Latitude 13° 8′						
	Sun Rises			Sun Sets.			Sun Rises.			Sun Sets.			
° ′	h	′	″	h	′	″	h	′	″	h	′	″	° ′
0	6	0	0	6	0	0	6	0	0	6	0	0	0
1	5	54	4	6	5	56	5	59	4	6	0	56	1
2	5	48	4	6	11	56	5	58	8	6	1	52	2
3	5	42	4	6	17	56	5	57	12	6	2	48	3
4	5	36	8	6	23	52	5	56	16	6	3	44	4
5	5	30	4	6	29	56	5	55	20	6	4	40	5
6	5	24	0	6	36	0	5	54	24	6	5	36	6
7	5	18	48	6	41	12	5	53	24	6	6	36	7
8	5	11	40	6	48	20	5	52	28	6	7	32	8
9	5	5	28	6	54	32	5	51	32	6	8	28	9
10	4	59	8	7	0	52	5	50	36	6	9	24	10
11	4	52	40	7	7	20	5	49	36	6	10	24	11
12	4	46	12	7	13	48	5	48	36	6	11	24	12
13	4	39	16	7	20	24	5	47	40	6	12	20	13
14	4	32	48	7	27	12	5	46	40	6	13	20	14
15	4	25	56	7	34	4	5	45	40	6	14	20	15
16	4	18	52	7	41	8	5	44	40	6	15	20	16
17	4	11	40	7	48	20	5	43	40	6	16	20	17
18	4	4	16	7	55	44	5	42	36	6	17	24	18
19	3	56	40	8	3	20	5	41	36	6	18	24	19
20	3	48	44	8	11	16	5	40	32	6	19	28	20
21	3	41	36	8	19	24	5	39	28	6	20	32	21
22	3	32	4	8	27	56	5	38	20	6	21	40	22
23	3	23	12	8	36	48	5	37	16	6	22	44	23
23 29	3	18	48	8	41	12	5	36	44	6	23	16	23 29
	Sun Sets			Sun Rises.			Sun Sets.			Sun Rises.			

Sun's Declination North.

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.	Gibraltar Latitude 36° 30′						Hamburgh Latitude 53° 57′						Sun's Declination South.
	Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets			
°	h	′	″	h	′	″	h	′	″	h	′	″	°
0	6	0	0	6	0	0	6	0	0	6	0	0	0
1	5	57	4	6	2	56	5	54	32	6	5	28	1
2	5	54	4	6	5	56	5	49	0	6	11	0	2
3	5	51	4	6	8	56	5	43	28	6	16	32	3
4	5	48	8	6	11	52	5	37	56	6	22	4	4
5	5	45	12	6	14	48	5	32	24	6	27	36	5
6	5	42	12	6	17	48	5	26	48	6	33	12	6
7	5	39	8	6	20	52	5	21	8	6	38	52	7
8	5	36	8	6	23	52	5	15	28	6	44	32	8
9	5	33	8	6	16	52	5	9	44	6	50	16	9
10	5	30	0	6	30	0	5	3	56	6	56	4	10
11	5	26	56	6	33	4	4	58	4	7	1	56	11
12	5	23	48	6	36	12	4	52	4	7	7	56	12
13	5	20	40	6	39	20	4	46	0	7	14	0	13
14	5	17	32	6	42	28	4	39	52	7	20	8	14
15	5	14	16	6	45	44	4	33	36	7	26	24	15
16	5	11	0	6	49	0	4	27	12	7	32	48	16
17	5	7	44	6	52	16	4	20	40	7	39	20	17
18	5	4	20	6	55	40	4	13	56	7	46	4	18
19	5	0	56	6	59	4	4	7	4	7	52	56	19
20	4	57	32	7	2	28	4	0	0	8	0	0	20
21	4	54	0	7	6	0	3	52	40	8	7	20	21
22	4	50	24	7	9	36	3	45	8	8	14	52	22
23	4	46	48	7	13	12	3	37	20	8	22	40	23
23 29	4	45	0	7	15	0	3	33	24	8	26	36	23 29
	Sun Sets.			Sun Rises			Sun Sets			Sun Rises.			

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.	Hanover Latitude 52° 35'						Jamaica Latitude 18° 25'						Sun's Declination South.
	Sun Rises			Sun Sets.			Sun Rises.			Sun Sets.			
°	h	'	"	h	'	"	h	'	"	h	'	"	° '
0	6	0	0	6	0	0	6	0	0	6	0	0	0
1	5	54	48	6	5	12	5	58	40	6	1	20	1
2	5	49	32	6	10	28	5	57	24	6	2	36	2
3	5	44	20	6	15	40	5	56	8	6	3	52	3
4	5	39	4	6	20	56	5	54	52	6	5	8	4
5	5	34	24	6	25	36	5	53	28	6	6	32	5
6	5	28	24	6	31	36	5	52	0	6	8	0	6
7	5	23	4	6	36	56	5	50	44	6	9	16	7
8	5	17	40	6	42	20	5	49	20	6	10	40	8
9	5	12	16	6	47	44	5	48	0	6	12	0	9
10	5	6	44	6	53	16	5	46	40	6	13	20	10
11	5	1	8	6	58	52	5	45	20	6	15	40	11
12	4	55	28	7	4	32	5	43	48	6	16	12	12
13	4	49	44	7	19	16	5	42	32	6	17	28	13
14	4	43	56	7	16	4	5	41	0	6	19	0	14
15	4	38	0	7	22	0	5	39	40	6020	20	20	15
16	4	31	56	7	28	4	5	38	8	6	21	52	16
17	4	25	48	7	34	12	5	36	44	6	23	16	17
18	4	19	28	7	40	32	5	35	16	6	24	44	18
19	4	13	0	7	47	0	5	33	48	6	26	12	19
20	4	6	24	7	53	36	5	32	12	6	27	48	20
21	3	59	32	8	0	28	5	30	40	6	29	20	21
22	3	52	28	8	7	32	5	29	12	6	30	48	22
23	3	45	12	8	14	48	5	27	28	6	32	32	23
23 29	3	41	36	8	18	24	5	26	44	6	33	16	23 29
	Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.			

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Jerusalem Latitude 32° 30′						Kelmar Latitude 56° 40′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Rises				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	57	28	6	2	32	5	53	56	6	6	4	1	
2		5	54	52	6	5	8	5	47	48	6	12	12	2	
3		5	52	20	6	7	40	5	41	44	6	18	16	3	
4		5	49	48	6	10	12	5	35	36	6	24	24	4	
5		5	47	12	6	12	48	5	29	28	6	30	32	5	
6		5	44	40	6	15	20	5	23	4	6	36	56	6	
7		5	42	0	6	18	0	5	17	0	6	43	0	7	
8		5	39	38	6	20	22	5	10	40	6	49	20	8	
9		5	36	52	6	23	8	5	4	16	6	55	44	9	
10		5	34	12	6	25	48	4	57	48	7	2	12	10	
11		5	31	36	6	28	24	4	51	16	7	8	44	11	
12		5	28	52	6	31	8	4	44	36	7	15	24	12	
13		5	26	0	6	34	0	4	37	48	7	22	12	13	
14		5	23	24	6	36	36	4	30	56	7	29	4	14	
15		5	20	40	6	39	20	4	23	52	7	36	8	15	
16		5	17	56	6	42	4	4	16	36	7	43	24	16	
17		5	15	4	6	44	56	4	9	12	7	50	48	17	
18		5	12	12	6	47	48	4	1	36	7	58	24	18	
19		5	9	20	6	50	40	3	53	44	8	6	16	19	
20		5	6	24	6	53	36	3	45	36	8	14	24	20	
21		5	3	28	6	58	32	3	37	12	8	22	48	21	
22		5	1	20	6	59	40	3	28	24	8	31	36	22	
23		4	57	12	7	2	48	3	19	16	8	40	44	23	
23	29	4	55	44	7	4	16	3	14	36	8	45	24	23	29
		Sun Se .			Sun Rise			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Leverpool Latitude 53° 22'						Lisbon Latitude 38° 45'						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets.				
°	'	h	'	"	h	'	"	h	'	"	h	'	"	°	'
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	54	36	6	5	24	5	56	48	6	3	12	1	
2		5	49	16	6	10	44	5	53	36	6	6	24	2	
3		5	43	52	6	16	8	5	50	20	6	9	40	3	
4		5	38	24	6	21	36	5	47	48	6	12	12	4	
5		5	33	0	6	27	0	5	43	56	6	16	4	5	
6		5	27	28	6	32	32	5	41	36	6	19	24	6	
7		5	22	0	6	32	0	5	37	24	6	22	36	7	
8		5	16	24	6	43	36	5	34	8	6	25	52	8	
9		5	10	48	6	49	12	5	31	48	6	29	12	9	
10		5	5	8	6	54	52	5	27	28	6	32	32	10	
11		4	59	24	7	0	36	5	24	24	8	35	36	11	
12		4	53	32	7	6	28	5	20	44	6	39	16	12	
13		4	47	40	7	12	20	5	17	16	6	42	44	13	
14		4	41	40	7	18	20	5	13	38	6	46	22	14	
15		4	35	32	7	24	28	5	10	20	6	49	40	15	
16		4	29	16	7	30	44	5	6	48	6	53	12	16	
17		4	22	52	7	37	8	5	3	12	6	46	48	17	
18		4	16	20	7	43	40	4	59	32	7	0	28	18	
19		4	9	40	7	50	20	4	55	48	7	4	12	19	
20		4	2	48	7	57	12	4	52	4	7	7	56	20	
21		3	55	40	8	4	20	4	48	4	7	11	56	21	
22		3	48	24	8	11	36	4	44	16	7	15	44	22	
23		3	40	44	8	19	16	4	40	20	7	19	40	23	
23	29	3	37	0	8	23	0	4	38	44	7	21	16	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		London Latitude 51° 32′						Madrid Latitude 40° 10′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets.				
°	′	h.	′	″	h	′	″	h.	′	″	h.	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	55	16	6	4	44	5	56	36	6	2	24	1	
2		5	49	56	6	10	4	5	53	16	6	6	44	2	
3		5	44	52	6	15	8	5	49	52	6	10	8	3	
4		5	39	48	6	20	12	5	46	28	6	13	32	4	
5		5	34	44	6	25	16	5	43	4	6	16	56	5	
6		5	29	36	6	30	24	5	39	40	6	20	20	6	
7		5	24	24	6	35	36	5	36	8	6	23	52	7	
8		5	19	16	6	40	44	5	32	48	6	27	12	8	
9		5	14	0	6	46	0	5	29	16	6	30	44	9	
10		5	8	44	6	51	16	5	25	44	6	34	16	10	
11		5	3	20	6	56	40	5	22	16	6	37	44	11	
12		4	57	56	7	2	4	5	18	40	6	41	20	12	
13		4	52	28	7	7	32	5	15	0	6	45	0	13	
14		4	46	52	7	13	8	5	11	24	6	48	36	14	
15		4	41	8	7	18	52	5	7	44	6	52	16	15	
16		4	35	24	7	24	36	5	4	0	6	56	0	16	
17		4	29	28	7	30	32	5	0	12	6	59	48	17	
18		4	23	28	7	36	32	4	56	20	7	3	40	18	
19		4	17	16	7	42	44	4	52	24	7	7	36	19	
20		4	10	56	7	49	4	4	48	24	7	11	36	20	
21		4	4	28	7	55	32	4	44	24	7	15	36	21	
22		3	57	44	8	2	16	4	40	16	7	19	44	22	
23		3	50	52	8	9	8	4	36	40	7	23	56	23	
23	29	3	47	24	8	12	36	4	33	56	7	26	4	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Muscow Latitude 55° 25′						New-York. Latitude 41° 40′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises			Sun Sets.				
°	′	h	′	″	h.	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	54	12	6	5	48	5	56	24	6	3	36	1	
2		5	48	24	6	11	36	5	52	52	6	7	8	2	
3		5	42	16	6	17	44	5	49	20	6	10	40	3	
4		5	36	44	6	23	16	5	45	44	6	14	16	4	
5		5	30	52	6	29	8	5	42	8	6	17	52	5	
6		5	24	56	6	35	4	5	38	32	6	21	28	6	
7		5	19	0	6	41	0	5	34	56	6	25	4	7	
8		5	13	0	6	47	0	5	31	16	6	28	44	8	
9		5	6	52	6	53	8	5	27	36	6	32	24	9	
10		5	0	44	6	59	16	5	33	56	6	36	4	10	
11		4	54	32	7	5	28	5	20	12	6	39	48	11	
12		4	48	8	7	11	52	5	16	24	6	33	36	12	
13		4	41	48	7	18	12	5	12	32	6	47	28	13	
14		4	35	12	7	24	48	5	8	44	6	51	16	14	
15		4	28	32	7	31	28	5	6	0	6	54	0	15	
16		4	21	44	7	38	16	5	0	22	6	59	38	16	
17		4	14	44	7	45	16	4	56	32	7	3	28	17	
18		4	7	32	7	52	28	4	52	58	7	7	2	18	
19		4	0	8	7	59	52	4	48	36	7	11	24	19	
20		3	52	32	8	7	28	4	46	4	7	13	56	20	
21		3	44	40	8	15	20	4	40	8	7	19	52	21	
22		3	36	28	8	23	32	4	35	44	7	24	16	22	
23		3	28	0	8	32	0	4	31	24	7	28	36	23	
23	29	3	23	44	8	36	16	4	29	0	7	31	0	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

	North-Cape Latitude 71° 25′						Oxford Latitude 51° 46′						
	Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets.			
°	h	′	″	h	′	″	h	′	″	h	′	″	°
0	6	0	0	6	0	0	6	0	0	6	0	0	0
1	5	48	8	6	11	52	5	54	56	6	5	4	1
2	5	36	8	6	23	52	5	49	52	6	10	8	2
3	5	24	8	6	35	52	5	44	44	6	15	16	3
4	5	12	0	6	48	0	5	39	40	6	20	20	4
5	4	59	40	7	0	20	5	34	32	6	25	28	5
6	4	47	8	7	12	52	5	29	20	6	30	40	6
7	4	34	20	7	25	40	5	24	8	6	35	52	7
8	4	21	12	7	38	48	5	18	56	6	41	4	8
9	4	7	36	7	52	24	5	13	36	6	46	24	9
10	3	53	28	8	6	32	5	7	40	6	52	20	10
11	3	38	44	8	21	16	5	2	52	6	57	8	11
12	3	23	8	8	36	52	4	57	24	7	2	36	12
13	3	6	32	8	53	28	4	51	52	7	8	8	13
14	2	48	32	9	11	28	4	46	12	7	13	48	14
15	2	28	36	9	31	24	4	40	28	7	19	32	15
16	2	5	56	9	54	0	4	34	40	7	25	20	16
17	1	38	20	10	21	40	4	28	40	7	31	20	17
18	0	49	36	11	0	2	4	22	44	7	37	16	18
19	S. Se. not			S.Ri. not			4	16	20	7	43	40	19
20	All Day and no Night.			All Night and no Day.			4	9	56	7	50	4	20
21							4	3	32	7	56	28	21
22							3	56	36	8	3	24	22
23							3	49	36	8	10	24	23
23 29							3	46	8	8	13	52	23 29
	Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.			

Sun's Declination North. — Sun's Declination South.

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Paris Latitude 48° 51'						Rome Latitude 41° 50'						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises			Sun Sets.				
°	'	h	'	"	h	'	"	h	'	"	h	'	"	°	'
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	55	28	6	4	32	5	56	24	6	3	36	1	
2		5	50	32	6	9	28	5	52	40	6	7	20	2	
3		5	46	16	6	13	44	5	46	48	6	13	32	3	
4		5	41	40	6	18	20	5	45	36	6	14	24	4	
5		5	37	0	6	23	0	5	42	4	6	17	56	5	
6		5	32	20	6	27	40	5	38	24	6	21	36	6	
7		5	27	40	6	32	20	5	34	48	6	25	12	7	
8		5	22	56	6	37	4	5	31	8	6	28	52	8	
9		5	18	12	6	41	48	5	27	24	6	32	36	9	
10		5	13	28	6	46	32	5	23	40	6	36	20	10	
11		5	8	36	6	51	24	5	19	56	6	40	4	11	
12		5	3	40	6	56	20	5	16	8	6	43	52	12	
13		5	58	44	7	1	10	5	12	20	6	47	40	13	
14		4	53	40	7	6	20	5	8	24	6	51	36	14	
15		4	48	36	7	11	44	5	4	28	6	55	32	15	
16		4	43	24	7	16	36	5	0	32	6	59	28	16	
17		4	38	4	7	21	56	4	56	28	7	3	32	17	
18		4	32	40	7	27	20	4	52	24	7	7	36	18	
19		4	27	12	7	32	48	4	48	12	7	11	48	19	
20		4	21	32	7	38	28	4	43	56	7	16	4	20	
21		4	15	48	7	44	12	4	39	36	7	20	24	21	
22		4	9	52	7	50	8	4	35	12	7	24	48	22	
23		4	3	44	7	56	16	4	30	40	7	29	20	23	
23	29	4	0	48	7	59	12	4	28	28	7	31	32	23	29
		Sun Sets.			Sun Rises.			Sun Sets			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		St Christophers Latitude 17° 30′						Stockholm Latitude 59° 26′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets.				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	48	44	6	1	16	5	53	12	6	6	48	1	
2		5	47	28	6	2	32	5	46	28	6	13	32	2	
3		5	56	12	6	3	48	5	39	40	6	20	20	3	
4		5	55	0	6	5	0	5	32	38	6	27	12	4	
5		5	53	40	6	6	20	5	25	56	6	34	4	5	
6		5	52	24	6	7	36	5	19	0	6	41	0	6	
7		5	51	8	6	8	52	5	13	8	6	46	52	7	
8		5	49	52	6	10	8	5	4	56	6	55	4	8	
9		5	48	32	6	11	28	4	57	48	6	2	12	9	
10		5	47	16	6	12	44	4	50	32	7	9	28	10	
11		5	45	56	6	14	4	4	43	16	7	16	44	11	
12		5	44	36	6	15	24	4	35	40	7	24	20	12	
13		5	43	16	6	16	44	4	27	56	7	32	4	13	
14		5	41	56	6	18	4	4	20	8	7	39	52	14	
15		5	40	36	6	19	24	4	12	4	7	47	56	15	
16		5	39	16	6	20	44	4	3	52	7	56	8	16	
17		5	37	2	6	22	8	3	55	16	8	4	44	17	
18		5	36	28	6	23	32	3	46	28	8	13	32	18	
19		5	35	4	6	24	56	3	37	20	8	22	40	19	
20		5	33	36	6	26	24	3	27	48	8	32	12	20	
21		5	32	12	6	27	48	3	17	52	8	42	8	21	
22		5	31	44	6	29	16	3	7	20	8	52	40	22	
23		5	29	16	6	30	44	2	56	12	8	3	48	23	
23	29	5	28	32	6	31	28	2	50	48	8	9	24	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Vienna Latitude 48° 14′						Virginia Latitude 37° 47′						Sun's Declination South.	
		Sun Rises.			Sun Sets.			Sun Rises.			Sun Sets				
°	′	h	′	″	h	′	″	h	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	55	32	6	4	28	5	56	48	6	3	12	1	
2		5	51	4	6	8	56	5	53	40	6	6	20	2	
3		5	46	48	6	13	12	5	50	24	6	9	36	3	
4		5	42	8	6	17	52	5	47	16	6	12	44	4	
5		5	37	32	6	22	28	5	44	36	6	15	24	5	
6		5	33	4	6	26	56	5	41	8	6	18	52	6	
7		5	28	36	6	31	24	5	38	0	6	22	0	7	
8		5	24	4	6	35	56	5	35	0	6	25	0	8	
9		5	19	28	6	40	32	5	31	56	6	28	4	9	
10		5	14	28	6	45	32	5	27	52	6	32	8	10	
11		5	11	0	6	49	0	5	24	36	6	35	24	11	
12		5	5	4	6	54	56	5	21	12	6	38	48	12	
13		5	0	4	6	59	56	5	17	48	6	42	12	13	
14		4	55	16	7	4	44	5	14	24	6	45	36	14	
15		4	50	12	7	9	48	5	10	56	6	49	4	15	
16		4	45	24	7	14	36	5	7	32	6	52	28	16	
17		4	40	16	7	19	44	5	3	52	6	56	8	17	
18		4	34	40	7	25	20	5	0	16	6	59	44	18	
19		4	28	12	7	31	48	4	57	0	7	3	0	19	
20		4	23	48	7	36	12	4	52	52	7	7	8	20	
21		4	18	12	7	41	48	4	49	24	7	10	36	21	
22		4	12	24	7	47	36	4	46	12	7	13	48	22	
23		4	6	32	7	53	28	4	42	52	7	17	8	23	
23	29	4	3	36	7	56	24	4	39	24	7	20	36	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises.				

A perpetual Table of the Sun's Rising and Setting for these Places. True Time.

Sun's Declination North.		Warsaw Latititude 52° 14′						York Latitude 54° 0′						Sun's Declination South.	
		Sun Rise			Sun Sets.			Sun Rises.			Sun Sets				
°	′	h	′	″	h	′	″	h.	′	″	h	′	″	°	′
0		6	0	0	6	0	0	6	0	0	6	0	0	0	
1		5	54	52	6	5	8	5	54	32	6	5	28	1	
2		5	49	40	6	10	20	5	49	0	6	11	0	2	
3		5	44	28	6	15	32	5	43	28	6	16	32	3	
4		5	39	16	6	20	44	5	37	56	6	22	4	4	
5		5	34	4	6	25	16	5	32	20	6	27	40	5	
6		5	28	48	6	31	12	5	26	44	6	33	16	6	
7		5	23	28	6	36	32	5	21	8	6	38	52	7	
8		5	18	12	6	41	48	5	15	24	6	44	36	8	
9		5	12	48	6	47	12	5	9	40	6	50	20	9	
10		5	7	24	6	52	36	5	3	48	6	56	12	10	
11		5	1	52	6	58	8	4	57	56	7	2	4	11	
12		4	56	20	7	3	40	4	51	56	7	8	4	12	
13		4	50	40	7	9	20	4	45	56	7	14	4	13	
14		4	44	20	7	15	40	4	39	44	7	20	16	14	
15		4	39	4	7	20	56	4	33	28	7	26	32	15	
16		4	33	8	7	26	52	4	27	0	7	33	0	16	
17		4	27	4	7	32	56	4	20	28	7	39	32	17	
18		4	20	48	7	39	12	4	13	44	7	46	16	18	
19		4	14	28	7	45	32	4	6	52	7	53	8	19	
20		4	7	56	7	52	4	3	59	44	8	0	16	20	
21		4	1	12	7	58	48	3	52	24	8	7	36	21	
22		3	54	16	8	5	44	3	44	52	8	16	8	22	
23		3	47	8	8	12	52	3	37	0	8	23	0	23	
23	29	3	43	46	8	16	24	3	33	8	8	26	52	23	29
		Sun Sets.			Sun Rises.			Sun Sets.			Sun Rises				

A TABLE

Of all the Eclipses, both Visible and Invisible of the Sun and Moon, that will happen from the Year 1728, to the Year 1764, under the Meridian of *London*.

Year	Months and Days	D	h	′	Long. ☽	°	′	Lat. ☽ °	′		Digits °	′	Visible or Invsible	Lumin.
1728	Febru.	13	19	14	♍	6	0	0	36	N D	9	13	Set. Ecl.	☽
	Febru.	28	8	0	♓	20	37	0	45	N A			Invisible	☉
	Aug.	8	5	0	♒	26	39	0	35	S D			Invisible	☽
	Aug.	23	13	0	♍	11	29	0	46	S A			Invisible	☉
1729	Jan.	17	18	39	♒	9	27	1	20	S D			Invisible	☉
	Febru.	2	8	44	♌	25	15	0	6	S A	19	17	Visible	☽
	Febru.	16	9	33	♓	9	22	1	23	N A			Invisible	☉
	July	14	13	58	♌	2	31	1	5	N D			Invisible	☉
	July	28	13	20	♒	16	15	0	8	N A	18	47	Visible	☽
1730	Jan.	7	6	37	♑	28	33	0	39	S D			Invisible	☉
	Jan.	22	15	34	♌	14	10	0	46	S A	2	53	Visible	☽
	July	3	15	26	♋	22	15	0	15	S A	6	7	Ris. ecli.	☉
	July	18	4	26	♒	6	7	0	53	N A			Invisible	☽
	Dec.	27	22	27	♑	17	45	0	2	N A			Invisible	☉
1731	June	8	13	55	♐	28	4	0	55	S D	1	52	Visible	☽
	June	22	17	57	♋	11	35	0	19	S A			Invisible	☉
	Dec.	1	22	45	♐	6	19	0	43	S D			Invisible	☽
	Dec.	17	13	5	♑	6	55	0	44	N A			Invisible	☉
1732	May	28	2	12	♐	17	15	0	14	S D			Invisible	☽
	June	11	0	0	♋	1	6	1	2	S A			Invisible	☉
	Nov.	6	4	53	♏	25	38	1	21	S D			Invisible	☉
	Nov.	20	9	59	♊	10	2	0	3	N D	20	48	Visible	☽
	Dec.	5	21	12	♐	25	48	0	32	N A	0	1	Visible	☉

The TABLE of Eclipses continued.

Year	Months and Days	D	h	'	Long. ☽	°	'	Lat. ☽ °	'		Digits °	'	Visible or Invisible	Lumin.
1733	May	2	6	37	♉	22	52	0	8	N D	9	20	Visible	☉
	May	17	6	56	♐	8	17	0	32	N A	8	35	Rise Ecl.	☽
	Octob.	26	4	44	♏	14	17	0	43	S D			Invisible	☉
	Nov.	10	1	6	♉	29	16	0	39	S A			Invisible	☽
1734	April	21	22	8	♉	12	39	0	3	N D			Invisible	☉
	Octob.	15	6	15	♏	3	4	0	4	S D			Invisible	☉
1735	March	26	22	41	♎	17	8	0	42	S D			Invisible	☽
	April	11	10	58	♉	2	7	0	40	S A			Invisible	☉
	Sept.	20	13	33	♈	8	18	0	39	N D	5	37	Visible	☽
	Octob.	4	14	40	♎	22	12	0	37	N A			Invisible	☉
1736	March	1	2	36	♓	22	21	1	17	N D			Invisible	☉
	March	15	11	52	♎	6	36	0	1	N A	21	45	Visible	☽
	March	30	19	2	♈	21	38	1	23	S A			Invisible	☉
	Aug.	24	21	30	♍	13	0	1	17	S D			Invisible	☉
	Sept.	8	14	24	♓	27	19	0	1	S A	20	32	Visible	☽
	Sept.	23	5	44	♎	11	40	1	19	N A	4	1	part visi.	☉
1737	Febru.	18	3	4	♓	11	9	0	39	N D	10	55	Visible	☉
	March	5	4	7	♍	25	59	0	43	N A			Invisible	☽
	Aug.	14	12	48	♍	2	39	0	33	S D			Invisible	☉
	Aug.	28	15	54	♓	16	22	0	42	S A	4	34	Visible	☽
1738	Febru.	7	5	7	♒	29	59	0	1	S A			Invisible	☉
	Aug.	3	23	3	♌	22	14	0	21	S D	4	8	Visible	☉
1739	Jan.	13	10	54	♌	4	38	0	37	S D	6	22	Visible	☽
	Jan.	27	16	4	♒	19	2	0	42	S A			Invisible	☉
	July	9	4	18	♑	27	16	0	26	N A			Invisible	☽
	July	24	4	23	♌	11	39	0	12	N D	7	6	Visible	☉
	Dec.	18	20	49	♑	8	19	0	27	N D	2	10	Visible	☉
1740	Jan.	2	10	25	♋	23	10	0	1	N A	20	29	Visible	☽
	Jan.	17	8	7	♒	8	20	1	24	S A			Invisible	☉
	June	12	14	20	♋	2	39	1	1	S D			Invisible	☉
	June	27	21	23	♑	17	16	0	19	S A			Invisible	☽
	Dec.	7	10	55	♐	27	27	0	39	N D			Invisible	☉
	Dec.	21	11	49	♋	11	46	0	40	N A	5	49	Visible	☽
1741	June	1	21	46	♊	22	16	0	49	S D			Invisible	☉
	Nov.	26	71	44	♐	16	16	0	1	S A			Invisible	☉

The TABLE of Eclipſes continued.

Year	Months and Days D h '	Long. ☽ ° '	Lat. ☽ ° '	Digits ° '	Viſible or Inviſible	Lumin.
1742	May 7 23 38	♏ 28 11	0 49 N D		Inviſible	☽
	May 22 12 42	♊ 12 8	0 28 N A		Inviſible	☉
	Nov. 1 0 30	♉ 19 58	0 43 S D		Inviſible	☽
	Nov. 15 18 15	♐ 4 53	0 39 S A		Inviſible	☉
1743	April 12 21 47	♉ 3 45	1 22 S D		Inviſible	☉
	April 27 3 21	♏ 17 32	0 7 N D		Inviſible	☽
	May 12 5 54	♊ 2 4	0 36 N A		Inviſible	☉
	Octob. 6 2 43	♎ 23 46	0 33 N D		Inviſible	☉
	Octob. 21 15 35	♉ 9 17	0 1 S D	21 30	Viſible	☽
	Nov. 4 18 27	♏ 23 30	1 17 S A		Inviſible	☉
1744	April 1 9 51	♈ 23 12	0 39 S D		Inviſible	☉
	April 15 8 32	♏ 6 51	0 35 S A	8 0	Viſible	☽
	Sept. 24 13 18	♎ 13 3	0 44 N D		Inviſible	☉
	Octob. 10 0 48	♈ 28 25	0 40 N A		Inviſible	☽
1745	March 21 14 56	♈ 12 28	0 2 N A		Inviſible	☉
	Sept. 14 5 2	♎ 2 37	0 1 N D		Inviſible	☉
1746	Feb. 24 3 44	♍ 16 59	0 37 N D	8 41	Viſible	☽
	March 10 14 54	♈ 1 22	0 42 N A		Inviſible	☉
	Aug. 19 12 5	♓ 7 18	0 39 S D	6 6	Viſible	☽
	Sept. 3 21 22	♍ 22 16	0 43 S A		Inviſible	☉
1747	Januar. 29 2 52	♒ 20 32	1 21 S D		Inviſible	☉
	Feb. 13 17 2	♍ 6 18	0 5 S A	19 42	Viſible	☽
	Feb. 27 17 18	♓ 20 18	1 21 N A		Inviſible	☉
	July 25 20 50	♌ 13 19	1 9 N D		Inviſible	☉
	Aug. 8 20 52	♒ 26 47	0 4 N A		Inviſible	☽
	Aug. 24 9 28	♍ 11 48	1 26 S A		Inviſible	☉
1748	Januar. 18 15 25	♒ 9 43	0 40 S D		Inviſible	☉
	Feb. 2 23 49	♌ 25 16	0 46 S A		Inviſible	☽
	July 13 22 30	♌ 2 38	0 4 N D	9 53	Viſible	☉
	July 28 11 34	♒ 16 32	0 49 N A	4 38	Viſible	☽
1749	Januar. 7 7 17	♑ 28 57	0 2 N A		Inviſible	☉
	June 18 21 34	♑ 8 31	0 59 S D		Inviſible	☽
	July 3 0 31	♋ 21 59	0 15 S A		Inviſible	☉
	Dec. 12 8 8	♋ 2 14	0 44 N D	4 36	Viſible	☽
	Dec. 27 21 12	♑ 18 6	0 13 S D	7 9	Viſible	☉

The TABLE of Eclipses continued.

Year	Months and Days.	D	h	′	Long. ☽	°	′	Lat. ☾ °	′		Digits °	′	Visible or Invisible	Lumin.
1750	June	8	9	9	♐	28	16	0	15	SD	16	9	Visible	☽
	June	22	6	51	♋	11	28	0	58	SA			Invisible	☉
	Nov.	17	13	19	♐	6	46	1	22	SD			Invisible	☉
	Dec.	1	18	32	♊	21	13	0	3	ND	21	6	Visible	☽
	Dec.	17	6	54	♑	7	1	1	23	ND			Invisible	☉
1751	May	13	2	51	♊	3	22	0	51	ND			Invisible	☉
	May	28	13	58	♐	17	44	1	28	NA	10	8	Visible	☽
	Nov.	6	12	43	♏	25	20	0	44	SD			Invisible	☉
	Nov.	21	9	47	♊	10	35	0	39	SA	8	18	Visible	☽
7752	May	2	5	45	♉	23	14	0	6	ND			Invisible	☉
	Octo.	25	13	59	♏	14	2	0	5	SD			Invisible	☉
1753	April	6	6	20	♎	27	52	0	45	SD	5	14	Ris. ecli.	☽
	April	21	19	37	♉	12	57	0	39	SA			Invisible	☉
	Sept.	30	21	36	♈	19	11	0	41	ND			Invisible	☽
	Octo.	14	21	59	♏	3	10	0	11	NA	8	3	Visible	☉
1754	Mar.	12	5	52	♍	18	14	1	29	SD			Invisible	☉
	Mar.	26	19	47	♎	17	24	0	2	SD	21	41	Invisible	☽
	April	10	22	17	♉	2	9	1	19	SA			Invisible	☉
	Sept.	5	1	13	♍	23	30	1	21	SD			Invisible	☉
	Sept.	19	22	28	♈	7	55	0	1	ND	21	12	Invisible	☽
	Octo.	4	13	31	♎	22	35	1	17	NA			Invisible	☉
1755	Mar.	1	9	45	♓	22	2	0	40	ND			Invisible	☉
	Mar.	16	12	12	♈	7	59	0	42	SA	7	13	Visible	☽
	Aug.	25	20	30	♍	13	19	0	37	SD			Invisible	☉
	Sept.	8	22	40	♓	27	4	0	34	SA			Invisible	☽
1756	Feb.	18	13	48	♓	10	58	0	8	ND			Invisible	☉
	Aug.	14	7	12	♍	2	52	0	7	NA			Invisible	☉
1757	Jan.	23	19	6	♌	15	48	0	38	SD	6	43	Set. Ecl.	☽
	Feb.	7	1	2	♓	0	9	0	41	SA			Invisible	☉
	July	19	11	53	♒	7	51	0	30	ND	11	32	Visible	☽
	Aug.	3	10	45	♌	22	10	0	49	NA			Invisible	☉
	Dec.	29	6	11	♑	19	33	1	20	ND			Invisible	☉
1758	Jan.	12	18	13	♌	4	20	0	0	NA	21	27	Set. Ecl.	☽
	Jan.	27	16	37	♒	19	28	0	23	SA			Invisible	☉
	June	23	20	55	♋	13	8	1	5	SD			Invisible	

The TABLE of Eclipses continued.

Year	Months and Days	D	h	′	″	Long. ☽ ° ′	Lat. ☽ ° ′		Digits ° ′	Visible or Invisible	Lumin.
1758	July	9	4	44		♑ 27 45	0 15	SA		Invisible	☽
	Dec.	18	19	29		♑ 8 40	0 40	ND		Invisible	☉
1759	Jan.	1	19	46		♋ 22 55	0 39	NA	6 41	Set. Ecl.	☽
	June	13	5	23		♋ 2 46	0 1	SD		Invisible	☉
	Dec.	8	2	14		♐ 27 29	0 0½	SA		Invisible	☉
1760	May	18	9	35		♐ 8 51	0 52	ND	0 47	Visible	☽
	June	1	19	22		♊ 22 36	0 20	SD	4 35	Visible	☉
	Nov.	11	9	18		♊ 1 8	0 44	SD	6 30	Visible	☽
	Nov.	26	2	2		♐ 16 2	0 38	SA		Invisible	☉
1761	April	23	5	40		♉ 14 33	1 24	SD		Invisible	☉
	May	7	10	2		♏ 28 3	0 11	ND	17 31	Visible	☽
	May	22	13	24		♊ 12 34	1 9	ND		Invisible	☉
	Octo.	16	10	29		♏ 4 14	1 27	NA		Invisible	☉
	Octo.	31	23	43		♉ 20 21	0 2	SD		Invisible	☽
	Nov.	15	2	15		♐ 4 38	1 16	SA		Invisible	☉
1762	April	12	17	28		♉ 3 58	0 42	SD		Invisible	☉
	April	26	15	36		♏ 17 26	0 32	SA	10 0	Visible	☽
	Octo.	5	20	12		♎ 24 0	0 16	ND	6 10	Visible	☉
	Octo.	21	5	11		♉ 9 25	0 39	NA	6 42	Visiible	☽
1763	April	1	22	15		♈ 23 12	0 1	SD		Invisible	☉
	Sept.	25	13	5		♎ 13 28	0 2	ND		Invisible	☉
1764	Mar.	11	47	15		♍ 27 56	0 39	ND	8 15	Visible	☽
	Aug.	20	22	9		♈ 12 10	0 4	SD	10 7	Visible	☉
	Sept.	29	19	18		♓ 18 0	0 42	SD		Invisible	☽
	Mar.	14	5	5		♎ 3 3	0 41	SA		Invisible	☉
1765	Feb.	8	11	45	0	♓ 14 0 32	1 21 18	SD		Invisible	☉
	Feb.	24	1	16	0	♍ 17 16 10	0 3 33	SA		Invisible	☽
	Mar.	10	1	0	28	♈ 0 11 0	1 19 13	NA		Invisible	☉
	Aug.	5	4	18	38	♑ 23 53 32	0 23 21	ND	2 42	Visible	☉
	Aug.	19	4	0	0	♓ 7 23 51				Invisible	☽
	Sept.	3	16	58	0	♍ 22 30 48				Invisible	☉
1766	Jan.	28	23	48	0	♒ 20 50 0				Invisible	☉
	Feb.	13	7	19	39	♍ 6 14 51	0 44 1	SA		Visible	☽
	July	25	6	41	25	♌ 13 11 25	0 20 36	S		Visible	☉
	Aug.	8	19	39	0	27 9 54				Invisible	☽

A TABLE of break of Day, Latitude 51° 32' N.

Days.	Janua. H	'	Feb. H	'	Mar. H	'	April H	'	May H	'	June. H	'
1	5	52	5	13	4	19	3	4	1	23	No Night but Twi-light.	
2	5	52	5	12	4	17	3	2	1	19		
3	5	51	5	10	4	15	2	59	1	14		
4	5	50	5	8	4	13	2	57	1	9		
5	5	49	5	6	4	11	2	54	1	4		
6	5	48	5	4	4	8	2	51	0	55		
7	5	47	5	2	4	6	2	49	0	53		
8	5	46	5	0	4	4	2	47	0	48		
9	5	45	4	59	4	2	2	44	0	40		
10	3	44	4	57	4	0	2	40	0	24		
11	5	42	4	55	3	57	2	35	0	14		
12	5	41	4	53	3	55	2	32	No Night.			
13	5	40	4	51	3	53	2	29				
14	5	39	4	50	3	50	2	26				
15	5	38	4	48	3	48	2	23				
16	5	36	4	47	3	45	2	19				
17	5	35	4	45	3	43	2	16				
18	5	34	4	43	3	40	2	12				
19	5	33	4	41	3	38	2	9				
20	5	32	4	39	3	35	2	6				
21	5	30	4	36	3	33	2	2				
22	5	29	4	34	3	31	1	49				
23	5	27	4	32	3	29	1	56				
24	5	25	4	30	3	26	1	53				
25	5	24	4	28	3	23	1	50				
26	5	22	4	25	3	20	1	47				
27	5	21	4	23	3	17	1	44				
28	5	19	4	21	3	14	1	39				
29	5	17			3	11	1	33				
30	5	16			3	8	1	28				
31	5	14			3	6						

Break of Day, Latitude 51° 32′ N.

Days.	July H	July ′	Aug. H	Aug. ′	Sept. H	Sept. ′	Octob. H	Octob. ′	Nov. H	Nov. ′	Dec. H	Dec. ′
1	No Night.		2	6	3	35	4	41	5	33	5	59
2			2	10	3	37	4	43	5	34	5	59
3			2	14	3	39	4	45	5	35	5	59
4			2	17	3	41	4	47	5	36	5	59
5			2	20	3	44	4	49	5	37	6	0
6			2	23	3	47	4	51	5	39	6	1
7			2	26	3	50	4	53	5	40	6	1
8			2	29	3	52	4	55	5	41	6	1
9			2	32	3	54	4	57	5	43	6	1
10			2	35	3	56	4	59	5	43	6	1
11	0	17	2	38	3	59	5	0	5	45	6	1
12	0	30	2	41	4	1	5	2	5	46	6	1
13	0	40	2	44	4	3	5	4	5	46	6	1
14	0	48	2	47	4	5	5	6	5	48	6	1
15	0	52	2	50	4	7	5	8	5	49	6	1
16	0	58	2	53	4	10	5	9	5	51	6	1
17	1	2	2	56	4	12	5	10	5	52	6	1
18	1	8	2	59	4	14	5	12	5	53	6	1
19	1	14	3	2	4	16	5	13	5	54	6	1
20	1	20	3	5	4	18	5	15	5	54	6	1
21	1	24	3	7	4	21	5	17	5	54	5	59
22	1	28	3	10	4	23	5	18	5	55	5	59
23	1	32	3	13	4	25	5	20	5	55	5	58
24	1	36	3	16	4	27	5	21	5	56	5	58
25	1	40	3	19	4	29	5	22	5	56	5	57
26	1	44	3	21	4	31	5	24	5	57	5	57
27	1	48	3	24	4	33	5	25	5	57	5	56
28	1	51	3	27	4	35	5	27	5	57	5	56
29	1	54	3	30	4	37	5	28	5	58	5	55
30	1	57	3	32	4	39	5	30	5	58	5	54
31	2	0	3	34			5	32			5	53

A TABLE of the End of Twi-light, Lat. 51° 32′ N.

Days.	Janua. H	Janua. ′	Feb. H	Feb. ′	March H	March ′	April H	April ′	May H	May ′	June. H	June. ′
1	6	8	6	47	7	41	8	56	10	37	No Night all this Month but Twi-light.	
2	6	8	6	48	7	43	8	58	10	41		
3	6	9	6	50	7	45	9	1	10	46		
4	6	10	6	52	7	47	9	3	10	51		
5	6	11	6	54	7	49	9	6	10	56		
6	6	12	6	56	7	52	9	9	11	2		
7	6	13	6	58	7	54	9	11	11	7		
8	6	14	7	0	7	56	9	13	11	12		
9	6	15	7	1	7	58	9	16	11	20		
10	6	16	7	3	8	0	9	20	11	36		
11	6	18	7	5	8	3	9	25	11	46		
12	6	19	7	7	8	5	9	28	No Night but Twi-light.			
13	6	20	7	9	8	7	9	31				
14	6	21	7	10	8	10	9	34				
15	6	22	7	12	8	12	9	37				
16	6	24	7	13	8	15	9	41				
17	6	25	7	15	8	17	9	44				
18	6	26	7	17	8	20	9	48				
19	6	27	7	19	8	22	9	51				
20	6	28	7	21	8	25	9	54				
21	6	30	7	24	8	27	9	58				
22	6	33	7	26	8	29	10	1				
23	6	34	7	28	8	31	10	4				
24	6	35	7	30	8	34	10	7				
25	6	36	7	32	8	37	10	10				
26	6	38	7	35	8	40	10	13				
27	6	39	7	37	8	43	10	16				
28	6	41	7	39	8	46	10	21				
29	6	43			8	49	10	27				
30	6	44			8	52	10	32				
31	6	46			8	54						

A Table of the End of Twi-light, Lat. 51° 32' N.

Days.	July H	July '	Aug. H	Aug. '	Sep. H	Sep. '	Octo. H	Octo. '	Nov. H	Nov. '	Dec. H	Dec. '
1	No Night but Twi-light.		9	54	8	25	7	19	6	27	6	1
2			9	50	8	23	7	17	6	26	6	1
3			9	46	8	21	7	15	6	25	6	1
4			9	43	8	19	7	13	6	24	6	1
5			9	40	8	16	7	11	6	23	6	0
6			9	37	8	13	7	9	6	21	5	59
7			9	34	8	10	7	7	6	20	5	59
8			9	31	8	8	7	5	6	19	5	59
9			9	28	8	6	7	3	6	18	5	59
10			9	25	8	4	7	1	6	17	5	59
11	11	43	9	22	8	0	7	0	6	15	5	59
12	11	30	9	19	7	59	6	58	6	14	5	59
13	11	20	9	16	7	57	6	56	6	13	5	59
14	11	12	9	13	7	55	6	54	6	12	5	59
15	11	8	9	10	7	53	6	52	6	11	5	59
16	11	2	9	7	7	50	6	51	6	9	5	59
17	10	58	9	4	7	48	6	50	6	8	5	59
18	10	52	9	1	7	46	6	48	6	7	5	59
19	10	46	8	58	7	44	6	47	6	6	5	59
20	10	40	8	55	7	42	6	45	6	6	5	59
21	10	36	8	53	7	39	6	43	6	6	6	1
22	10	32	8	50	7	37	6	42	6	5	6	1
23	10	28	8	47	7	35	6	40	6	5	6	2
24	10	24	8	44	7	33	6	39	6	4	6	2
25	10	20	8	41	7	31	6	38	6	4	6	3
26	10	16	8	39	7	29	6	36	6	3	6	3
27	10	12	8	36	7	27	6	35	6	3	6	4
28	10	9	8	33	7	25	6	33	6	3	6	4
29	10	6	8	30	7	23	6	32	6	2	6	5
30	10	3	8	28	7	21	6	30	6	2	6	6
31	10	0	8	26			6	28			6	7

A TABLE *of the* Sun's *Declination and Amplitude to every fifth Day in the Second past* Leap-Year, Latitude 51°, 32′ N.

Mon.	Days.	Declin. °		′	Amplit. °		′
January.	1	21	South.	39	36	South.	23
	5	20		56	35		3
	10	19		54	33		10
	15	18		42	31		1
	20	17		21	28		39
	25	15		53	26		6
February.	1	13		39	22		19
	5	12		18	20		2
	10	10		31	17		4
	15	8		40	14		1
	20	6		47	10		57
	25	4		51	7		49
March.	1	3		17	5		26
	5	1		42	2		26
	10	0	North.	17	0	North.	27
	15	2		14	3		35
	20	4		11	6		44
	25	6		6	9		50
April.	1	8		43	14		6
	5	10		4	16		19
	10	11		53	19		20
	15	13		32	22		6
	20	15		6	24		45
	25	16		34	27		17
May.	1	18		10	30		5
	5	19		7	31		46
	10	20		13	33		45
	15	21		9	35		27
	20	21		57	36		56
	25	22		35	38		8
June.	1	23		11	39		16
	5	23		23	39		39
	10	23		29	39		50
	15	23		24	39		41
	20	23		9	39		12
	25	22		44	38		24

Mon.	Days.	Declin. °		′	Amplit. °		′
July.	1	22	North.	1	37	North.	3
	5	21		25	35		57
	10	20		32	34		19
	15	19		30	32		27
	20	18		19	30		20
	25	17		2	28		6
August.	1	15		1	24		17
	5	13		47	22		31
	10	12		10	19		48
	15	10		27	16		57
	20	8		40	14		1
	25	6		50	11		2
September.	1	4		12	6		45
	5	2		39	4		16
	10	0		42	1		8
	15	1	South.	15	2	South.	0
	20	3		11	5		7
	25	5		9	8		18
October.	1	7		26	12		0
	5	8		56	14		27
	10	10		45	17		27
	15	12		30	20		22
	20	14		10	23		10
	25	15		45	25		52
November.	1	17		46	29		23
	5	18		48	31		12
	10	19		59	33		19
	15	21		1	35		12
	20	21		52	36		47
	25	22		33	38		4
December.	1	23		8	39		10
	5	23		22	39		37
	10	23		29	39		50
	15	23		24	39		41
	20	23		8	39		10
	25	22		39	38		15

A TABLE

Of the Aspects of *Saturn* and *Jupiter*, From 1682, to 1821.

Days.	°
1682 October 9.	☌ ♄ ♃ ♌ 19.
1683 January 30.	☌ ♄ ♌ 17 R. ♃ ♌° 17 R.
1683 May 2.	☌ ♄ ♃ ♌ 14.
1686 December 23.	✱ ♄ ♎ 12. ♃ 12 ♐.
1688 March 11.	□ ♄ ♎ 22. ♃ ♑ 22.
1690 March 8.	△ ♄ ♏ 17 R. ♃ ♓ 17.
1692 June 12.	☍ ♄ ♐ 6 R. ♃ ♊ 6.
1692 December 3.	☍ ♄ ♐ 14. ♃ 14 ♊ R.
1693 April 22.	☍ ♄ ♐ 21. ♃ 21 ♊.
1695 August 23.	△ ♄ ♑ 8 R. ♃ 8 ♍.
1696 February 21.	△ ♄ ♑ 23. ♃ 23. ♍ R.
1696 July 6.	△ ♄ ♑ 23 R. ♃ ♍ 23.
1697 September 19.	□ ♄ ♒ 1 R. ♃ 1 ♏.
1698 May 24.	□ ♄ ♒ 19 R. ♃ 19 ♏.
1699 January 14.	✱ ♄ ♒ 20. ♃ 20 ♐.
1699 March 27.	✱ ♄ ♒ 28. ♃ 28 ♐ S. R.
1699 October 11.	✱ ♄ ♒ 25 R. ♃ 25 ♐.
1702 May 11 15^h 2'.	☌ ♈ 6. 42.
1705 August 13.	✱ ♄ S to R. 20 ♉. ♃ 20 ♋.
1707 September 24.	□ ♄ R. 18 ♊. ♃ 18 ♍.
1708 June 3.	□ ♄ 22 ♊. ♃ 22 ♍.
1708 July 16.	□ ♄ 27 ♊. ♃ 27 ♍.
1708 December 21.	△ ♄ 28 ♊. ♃ 28 ♎.
1709 March 24.	△ ♄ 27 ♊. ♃ 27 ♎ R.
1709 November 12.	△ ♄ R. 15 ♋. ♃ 15 ♏.
1710 July 18.	△ ♄ 22 ♋. ♃ 22 ♏.

Days.	• •
1713 February 14.	☍ ♄ 24 ♌. ♃ 24 ♒.
1713 September 8.	☍ ♄ 5 ♍. ♃ 5 ♓ R.
1714 January 2.	☍ ♄ 11 ♍ R. ♃ 11 ♓.
1715 June 27.	△ ♄ 19 ♍. ♃ 19 ♉.
1716 April 16.	△ ♄ 1 ♎ R. ♃ 1 ♊.
1718 April 23.	□ ♄ 27 ♎ R. ♃ 27 ♋.
1719 July 18.	✶ ♄ 7 ♏. ♃ 7 ♍.
1722 December 27.	☌ ♄ ♃ ♐ 23. 41.
1725 July 13.	✶ ♄ 18 ♑ R. ♃ 18 ♓ R.
1726 March 11.	✶ ♄ 1 ♒. ♃ 1 ♈.
1727 May 17.	□ ♄ 15 ♒ R. ♃ 15 ♉.
1728 July 13.	△ ♄ 25 ♒ R. ♃ 25 ♊.
1732 March 8.	☍ ♄ 6 ♈. ♃ 6 ♎ R.
1735 December 19.	△ ♄ 21 ♉. ♃ 21 ♑.
1736 Auguſt 6.	△ ♄ 11 ♊. ♃ 11 ♑ R.
1737 March 8.	□ ♄ 7 ♊. ♃ 7 ♓.
1738 January 1.	□ ♄ 20 ♊ R. ♃ 20 ♓.
1739 March 12.	✶ ♄ 3 ♋. ♃ 3 ♉.
1742 Auguſt 18d 8h 46′ 48″	☌ ♌ 26° 58′ 26″
1746 February 16.	✶ ♄ 13 ♎ R. ♃ 13 ♐.
1746 June 9.	✶ ♄ 8 ♎. ♃ 8 ♐ R.
1746 November 26.	✶ ♄ 24 ♎. ♃ 24 ♐.
1748 February 16.	□ ♄ 9 ♏ R. ♃ 9 ♒.
1749 April 11.	△ ♄ 18 ♏ R. ♃ 18 ♓.
1749 October 6.	△ ♄ 20 ♏. ♃ 20 ♓ R.
1750 February 8.	△ ♄ 2 ♐. ♃ 2 ♈.
1751 July 26.	☍ ♄ 7 ♐ R. ♃ 7 ♊.
1752 May 26.	☍ ♄ 22 ♐ R. ♃ 22 ♊.
1754 October 18.	△ ♄ 12 ♑. ♃ 12 ♍.
1754 December 18.	△ ♄ 18 ♑. ♃ 18 ♍.
1755 Auguſt 14.	△ ♄ 23 ♑ R. ♃ 23 ♍.
1756 April 21.	△ ♄ 10 ♒. ♃ 10 ♎ R.
1762 March 7.	☌ ♈ 12 19.
1782 October 26.	☌ ♐ 18. 22.
1802 July 9.	☌ ♍ 5. 48.
1821 June 5.	☌ ♈ 24. 8.

N. B. R. *Signifies* Retrograde, *and* S. Stationary.

SECT.

SECT. V.

Astronomical PRECEPTS, *in the Use of the following New Tables; shewing how to calculate the Equation of Time, Planets Places, Ingresses, Aphelions, Retrogradations, Eclipses, (both Particular and General) Occultations, Appulses, Transits, Immersions and Emersions of the Satellites, &c. for any Time and Place proposed.*

PRECEPT I.

To reduce any other Meridian to that of London, & contra.

THE *Epochas* or Radixes of the middle Motions of the Planets in the following Tables, are accommodated to the last Day of the *Julian* Year for the Meridian of *London.*

In the *Catalogue of Cities*, seek the Place desired, and right against it is the Elevation of the Pole, the Difference of Meridians from *London*, either East or West, as the Letters A or S, which signify *Add* and *Subtract*, denote: That Place with *A* against it lies to the East; and that with S, to the West of *London.*

Then suppose I am at *Rome*, and there at 8 o'Clock in the Morning it be required to calculate the Places of the Planets from these Tables: Before I can begin this Work, I must reduce the Time at *Rome*, to the Time at *London.*

In the Table of Places I find *Rome* lies 52′ to the East of *London*; therefore, contrary to the Title, *subt.* 52′ from the Time at *Rome*, gives the Time at *London.*

OPERA-

OPERATION.

	H.	M.
Time at *Rome*	8	00
Difference of Meridians ſubt.	0	52
Remains, the Time at *London*	7	08

Secondly, If it be 7 h. 8′ in the Morning at *London,* what Time is it then at *Rome?*

	H.	M.
Time at *London*	7	8
Difference Meridians add	0	52
Time at *Rome*	8	00

Thirdly, Admit at *Leverpool,* when it is there Noon, what Time is it then at *London?*

	H.	M.
Time at *Leverpool*	12	00
Difference of Meridians add	00	10
Time at *London*	12	10

Laſtly, Suppoſe at *London* to be 12 h. 10′; what Time is it then at *Leverpool?*

	H.	M.
Time at *London*	12	10
Difference Meridians ſub.	0	10
Time at *Leverpool*	12	0

Theſe are all the Varieties that can happen in this Precept.

PRECEPT II.

To find the Equation of Time; and to reduce the Equal Time to the Apparent, & contra.

I have told you in the *Definitions* what the Equation of Time is; and for this purpose I have Calculated two Tables, which you will find in Page 2 and 3, of Vol. 2: The first Part is gained by entring with the Sun's Place on the Head, if the Sun be in the first or third Quadrant of the Ecliptic, and the Degree on the Left-hand descending: But if the Sun be in the second or fourth Quadrant, then find the Sign he is in at the bottom, and the Degree on the Right-hand ascending; and in the Place of meeting is the first part of the Equation of Time in Minutes and Seconds.

Secondly, With the Sun's mean Anomaly, enter the Table in *Page* 3, finding the Sign on the Head, if he be in the first Semicircle of the Ellipsis; that is, if the mean Anomaly be 0, 1, 2, 3, 4, or 5 Signs, and the Degree on the Left-hand descending; but if the Sun (or Earth) be in the second Part of the Ellipsis; that is, if the mean Anomaly be 6, 7, 8, 9, 10, or 11 Signs, find the Sign at the bottom, and the Degree on the Right-hand ascending, and in the Place of meeting you have the second Part of the Equation of Time in Minutes and Seconds; which is to be added or subtracted as the Table directs: Then if both Parts add, or both subtract, their Sum; otherwise their Difference (according to their greater part) is the absolute Equation of Time.

Example. Anno 1728, *November* 5th Day at Noon, I demand the true Equation of Time.

		Deg.	*Min.*	*Sec.*		*Min.*	*Sec.*	
Sun's Place	♏	24	24	57	Gives	9	29	+ to = time.
Anomaly	4	17	31	00	Gives	5	19	+ to = time.
					Sum	14	48	Add to the E-

qual, or subtract from the apparent Time.

Or otherwise without the help of the Tables, you may at any time find the true Equation of Time thus:

By

By *Prob.* 3. find the Sun's right Aſcenſion to the time propoſed, and take the Difference between that and the Longitude, which ſhall be the firſt part of the Equation of Time, and is to be added to the apparent Time, when the Sun is in the ſecond or fourth Quadrants; but ſubtracted, if he be in the firſt or third.

The ſecond Part of the Equation of Time is the Elliptic Equation, taken out of the Table, *Pages* 28, 29, and 30, Vol. 2, which is to be added to the apparent Time in the laſt ſix Signs of mean Anomaly, and to be ſubtracted in the firſt ſix Signs.

When theſe two Parts are of the ſame kind, that is, both add, or both ſubtract their Sum; otherwiſe their Difference is the abſolute Equation of Time, which according to the greater part, added to, or ſubtracted from the apparent Time, you will have the Equal; but to reduce the Equal to the apparent, uſe the contrary Titles. See my *Uranoſcopia*.

Example. Anno 1728, *November* 5th at Noon, I would know the true Equation of Time?

	Deg.	*Min.*	*Sec.*
Sun's Longitude in Degree	234	24	57
Right Aſcenſion	232	2	29
Difference, is the firſt part of the Equation	2	22	28 ſub.
Elliptic Equation add	1	19	48 ſub.
Sum	3	42	48.

Which reduced into Time by the Table in *Page* 66, is 14 Minutes 49 Seconds 4 Thirds, the abſolute Equation of Time; which is to be added to the equal, or ſubtracted from the apparent Time.

PRECEPT III.

To Compute the true Longitude of the fixed Stars.

The Catalogue of fixed Stars I have rectified to the begining of the Year of Human Redemption 1727; therefore you have no more to do, than to take the Præceſſion of the Equinox out of the Tables, in *Pages* 4 and 5, Vol. 2, for any Interval of Years, and add it to the Place of the Star in the Catalogue for Time, after 1727; but ſubtract for Time before, and you will gain the true Longitude of the Star enquired after.

Example. *Anno* 1740, *January* 1, I would know the true Place of the *Pleiades?*

From 1727, to 1740, is 13 Years.

	Deg.	Min.	Sec.
1727 Place of the *Pleiades* is	♉ 26	10	58
13 Year Motions add		10	50
Place of the *Pleiades*	♉ 26	21	48

The like you are to observe for any other fixed Star in the Catalogue. And the Præcession of the Equinox is given any Year by Inspection.

PRECEPT IV.

To Calculate the true Place of the Sun.

1. From the Table of the Sun's mean Motion, write out the Longitude and Anomaly answering the Years, Months, Days, Hours, Minutes, and Seconds, (if occasion be) which added up severally, are the mean Motion of the Sun for the time proposed; remembring in Leap-year after *February* to take the Days of the Month on the Right-hand under *Bissextile.*

2. With the Sun's mean Anomaly thus collected, enter the Table of his Equation, with the Sign on the Head (if under 6 Signs) and the Degree in the first Column on the Left-hand descending; but if the Anomaly be more than 6 Signs, find the Sign at the Foot of the Table, and the Degree on the Right-hand ascending; and in the common Angle, or Place of meeting is the Elliptic Equation, and Logarithm of the Distance of the Sun from the Earth answering; which, according to the Title, added to, or subtracted from, the mean Longitude of the Sun before found, will give his true Place of the time proposed; ever observing to find the Equation and Logarithm answering the mean Anomaly, as has been shewn in *Page* 299.

Example. Let the Sun's true Place be required on *April* 7, 1740, at Noon?

OPE-

OPERATION.

Equal Time.	Long. ☉ S	°	'	"	Anom. ☉ S.	°	'	"		'	"	
1740	9	20	17	10	6	11	51	48	If	60	0 L.L. ☉	
April 7, B	3	6	35	37	3	6	35	20	Give	120	14771	
Mean Mot.	0	26	52	47	9	18	27	8	What	27 08	3446	
Equat. add		1	49	35					*Answer*	54	18217	to
Sun's Place	0	28	42	22	L. 5.002429				be added to the Log. of 9 S. 18° makes the true			

Log. ⊖ à ☉ answering the mean Anomaly.

Example 2. Let the Place of the Sun be required on *Anno* 1740, *August* 29 at 36' 46'' past 8 o'Clock in the Morning at *London*, Equal Time?

OPERATION.

Equal Time.	Long. ☉ S.	°	'	"	Anom. ☉ S.	°	'	"		°	"
Anno 1740	9	20	17	10	6	11	51	48	If	60	0 L. L. ☉
Aug. 28, *Biss*.	7	7	32	27	7	27	31	45	Give	0 42	19331
Hours 20			49	17			49	17	What	14 21	6213
Minutes 36			1	29			1	29	*Answ*.	0 10	25544
Seconds 46				2				2	This Proportional Part		
Mean Mot.	5	18	40	25	2	10	14	21	is added to the Equation		
Equat. Sub.		1	48	41	L. 5.002586				of 2 S. 10°, and the		
Sun's Place	5	16	51	44					Sum 1° 48' 46'', the true Equation.		

Example 3. Let the Place of the Sun be required 3949 Years before Christ, on the 17th Day of *April*, under the Meridian of *Babylon* at Noon, that being the supposed Time of the World's Creation.

In order to calculate the Places of the Planets to any given Time before Christ, subtract the Motion answering to as many Years as will bring in, or exceed the Number of Years intended, from the mean Motion answering to the first Year of Christ; and to the Remainder add the Motion of so many Years as will make up the Complement of the Number of Years you subtracted, to the given Number of Years before Christ. As in this Example, 40 + 11 = 51 sub. from 4000, leaves 3949.

Or

Or subtract the mean Motion from the first Year of Christ, which answers to the given Number of Years before Christ, having regard whether the Year be *Bissextile* or *Common*; and then to subtract the Motion of a Day more from the rest, as you may see by the Examples following.

Equal Time.	Long. ☉ S.	°	′	″	Anom. ☉ S.	°	′	″	
AnnoChrist. 1	9	7	53	10	6	29	53	40	
4000 Years.	1	00	13	20	10	20	13	20	
Ant.Ch. 4000	8	7	39	50	8	9	40	20	sub.
40	0	0	18	8	11	29	36	8	
11	11	29	20	38	11	29	9	5	
Radix 3949	8	7	18	36	8	8	25	33	
Ap. 17, Com.	5	15	27	52	3	15	27	34	
X M. 3h. 14′.			7	59			7	59	
Mean Mot.	11	22	54	27	11	24	01	6	
Equation add			11	53					
Sun's Place.	11	23	6	20					

By which it appears that the Sun did not enter *Aries* till about the 24th Day of *April*, at the Creation.

Or you may Work thus.

Years.	*S.*	*Deg.*	*Min.*	*Sec.*	*S.*	*Deg.*	*Min.*	*Sec.*	
3000	00	22	40	00	11	00	10	00	
900	00	6	48	00	11	21	3	00	
40	00	00	18	8	11	29	36	8	
9	11	29	49	18	11	29	39	51	
3949 Motion	00	29	35	26	10	20	58	59	sub.
1 Year Xt.	9	7	53	10	6	29	53	40	from
Rem.	8	8	17	44	8	9	24	41	
Sub. one Days Motion			59	8			59	8	
Radix	8	7	18	36	8	8	25	33	as before :

So 'tis needless to proceed any further; for the Sun's Place will be the same as was just now found, ♓ 23° 6′ 20″.

PRE-

PRECEPT V.

To Calculate the Sun's Ingress into any of the Twelve Signs.

In order to make this Work as short and plain as possible, I have here underneath given the Elliptic Equation when the Sun enters every one of the 12 Zodiacal Signs for the Year 1728, which are to be added or subtracted to or from the Sun's mean Longitude of any given Year, the Sum or Difference subtracted from the Number of the Sign you are seeking the Sun's entrance into; and from that subtract the nearest less Day, Hour, Minute, and Seconds, in the Tables of mean Motion, and you will speedily gain the true time of the Sun's Ingress into the same Sign; as the following Examples will make plain.

The Table of Elliptic Equation, when the Sun enters into each Point of each Sign.

1728

	Deg.	*Min.*	*Sec.*	
♒	0	42	39	add
♓	1	30	41	add
♈	1	54	55	add
♉	1	48	32	add
♊	1	12	41	add
♋	0	16	50	add
♌	0	43	40	sub.
♍	1	32	6	sub.
♎	1	55	20	sub.
♏	1	47	31	sub.
♐	1	11	17	sub.
♑	0	16	25	sub.

Add to, or Subtract from the Sun's Mean Longitude for any given Year.

Example. Let the true Time of the Sun's Ingress into *Aries* be required, *Anno* 1728?

The

The Work stands thus:

	S.	Deg.	Min.	Sec.	*Thirds.*
Anno 1728, Sun's Mean Longitude	9	20	11	43	
Equation add		1	54	55	
Sum Sub.	9	22	6	38	
From *Aries*	12	0	0	0	
Rem.	2	7	53	22	
March 8, Bissext. sub.	2	7	1	26	
Rem.			51	56	
Hours 21 sub.			51	45	
Rem.				11	
Minutes 4 sub.				9	51
Rem.				1	9
Seconds 28 sub.				1	9
					0

By which it appears, that the Equal Time of the Sun's Entrance into the Equinoctial Sign ♈ at *London* 1728, is *March* 8 Days 21 Hours 2 Minutes 28 Seconds. At which time the Sun's mean Anomaly is 8 S. 19 Degrees 52 Minutes 5 Seconds, which gives the Equation of Time 7 Minutes 20 Seconds, to be subtracted from the Equal Time 8 Days 21 Hours 2 Minutes 28 Seconds: Therefore the apparent Time of the Vernal Equinox is *March* 8 Days 20 Hours 56 Minutes 28 Seconds.

And if any Gentlemen that is Qualified, and fitted with proper Instruments, did observe the same, I do not at all doubt but that the Event did very nearly answer.

And after the same manner have I found the Equal Times of the Sun's Ingress at *London* to be as follows, with the mean Anomaly at the same Time.

		D.	H.	M.	S.			☉'s Anom. S.	D.	M.	S.
1728	*Jan.*	9	5	25	37	☉ enters	♒	6	21	4	30
	Feb.	7	20	25	25		♓	7	20	16	24
	March	8	21	4	28		♈	8	19	52	5
	April	8	10	9	0		♉	9	19	58	24
	May	9	11	11	13		♊	10	20	34	11
	June	9	20	20	0		♋	11	21	29	58
	July	11	7	22	19		♌	0	22	30	24
	Aug.	11	13	30	49		♍	1	23	18	46
	Septem.	11	9	25	0		♎	2	23	41	56
	Octob.	11	16	44	15		♏	3	23	34	3
	Novem.	10	12	11	26		♐	4	22	57	45
	Decem.	10	0	44	25		♑	5	22	2	49
1729	*Jan.*	8	11	15	25	☉ enters	♒	6	21	3	27
	Feb.	7	2	14	12		♓	7	20	15	21
	March	9	2	53	10		♈	8	19	51	1
	April	8	15	57	0		♉	9	19	57	19
	May	9	15	59	14		♊	10	20	33	5
	June	10	2	7	42		♋	11	21	28	52
	July	11	13	10	33		♌	0	22	29	18
	Aug.	11	19	19	28		♍	1	23	17	41
	Septem.	11	15	14	0		♎	2	23	40	52
	Octob.	11	23	33	17		♏	3	23	33	0
	Novem.	10	18	20	0		♐	4	22	56	41
	Decem.	10	6	33	43		♑	5	22	1	47
1730	*Jan.*	8	17	5	17	☉ enters	♒	6	21	2	26
	Feb.	7	8	4	4		♓	7	20	14	19
	March	9	8	42	00		♈	8	19	49	58
	April	8	21	45	51		♉	9	19	56	16
	May	9	2	47	00		♊	10	20	32	00
	June	10	7	56	00		♋	11	21	27	47
	July	11	18	59	00		♌	0	22	28	13
	Aug.	12	1	7	18		♍	1	23	16	36
	Septem.	11	21	3	00		♎	2	23	49	48
	Octob.	12	4	22	19		♏	3	23	31	57
	Novem.	11	00	10	00		♐	4	42	55	41
	Decem.	10	12	23	25		♑	5	22	00	46

By reaſon of the Motion of the Earth's Aphelion and Nodes, the Elliptic Equation is never the ſame again when the Sun enters the ſame Sign, *&c.* for by Calculation I have proved that in 72 Years time, the difference of the Equation in the ſame part of the Orbit, is, as is here ſet down.

	Sign	Min.	Sec.		
When ☉ enters	♒	2	22	ſub.	to, or from the Equations of the Year 1728 in 72 Years; and ſo Proportionable for any intermediate Years.
	♓	1	37		
	♈	0	25		
	♉	0	53	add	
	♊	2	01		
	♋	2	34		
	♌	2	24	ſub.	
	♍	1	35		
	♎	0	22		
	♏	0	57	add	
	♐	1	58		
	♑	2	30		

Example. I demand the time of the Sun's Ingreſs into the Tropical Sign *Capricorn, Anno* 1740? First 1740 — 1728 = 12 Years?

Then ſay, As 72 Y : 2 Min. 30 Sec. :: 12 Y : 25 Seconds. This is to be added to the Elliptic Equation of the Year 1728, 16 Min. 25 Sec. in *Capricorn*, and it makes 16 Min. 50 Sec. for the Elliptic Equation in *Capricorn* for the Year 1740.

Now

Now the Operation stand thus:

	S.	Deg.	Min.	Sec.		
Anno 1740, Sun's Longitude	9	20	17	10		
Equation for 1740 sub.			16	50		
Rem. sub.	9	20	00	20		
From ♑.	9	0	0	0		
Rem.	11	9	59	40		
Dec. 9 Bissextile sub.	11	9	3	45		
Rem.			55	55		
Hours 22 sub.			54	13		
Rem.			1	42	*Thirds.*	
Minutes 41 sub.			1	41	2	
Rem.					58	*Fourths.*
Seconds 23 sub.					56	40
Rem.					1	20
Thirds 32 sub.					1	19
Rem.						1
Fourths 25 sub.						1
Rem.						0

By this Calculation it appears that the Sun will enter *Capricorn Anno* 1740, at *London*, *December* 9 Days 22 Hours 41 Minutes 23 Seconds 32 Thirds 25 Fourths, equal Time, the Anomaly at that Time being 5 S. 21 Degrees 50 Minutes 44 Seconds, which gives the Equation of Time 1 Minute 7 Seconds to be added to the equal Time, which makes the apparent Time of this Solar Ingress on *December* the 9th, 22 Hours 42 Minutes 30 Seconds 32 Thirds 25 Fourths.

Example 2. I demand the Sun's Entrance into ♍ 16 Degrees 26 Minutes 25 Seconds *Anno* 1741?

In the beginning of this Precept I have shewn how to find the Sun's entrance into the 12 Signs, and those Equation in *Page* 376, are adapted purely for those Points, so that in any

 other

other part of the Ecliptic that Method will not do; therefore in this Case it is best to consider between what two Days at Noon the Sun will (apparently) be in such a Degree as is required, which in this Case I find to be some Time between the 28th and 29th Day of *August* at Noon: On which Days Calculate the Sun's true Place by Precept 4, and on the 28th Day of *August* at Noon, I find to be ♍ 15 Degrees 47 Minutes 24 Seconds, that is, 39 Minutes 1 Second short of ♍ 16 Degrees 26 Minutes 25 Seconds, the Point of the Ecliptic sought; and on the 29th Day at Noon, his Place is ♍ 16 Degrees 45 Minutes 39 Seconds, the Sun's Diurnal Motion is now 58 Minutes 15 Seconds. Now say, if the Diurnal Motion 58 Minutes 58 Seconds gives 24 Hours,

What will the Distance 39 Minutes 1 Second, from the 28th Day at Noon give,

Answer, 16° 4′ 45″. See the Work.

	Deg.	*Min.*	*Sec.*	
If the Sun's Diurnal Motion C. A.	00	58	15	LL 871
Give	24	00	00	3979
What will the Distance give	00	39	01	1869
Answer	16	4	45	5719

The above Proportion supposes the Sun to move equally all the 24 Hours, but because it doth not so, what comes out will scarcely ever be the true Answer, therefore to the Time there found, Calculate the true Place of the Sun, and you will find it to be ♍ 16° 26′ 32″, that is, 7″ too much for the given Place; so that the exact Time that the Sun is in ♍ 16° 26′ 25″ is *August* 28 D. 16 H. 2′ P M.

PRECEPT VI.

To Calculate the true Place of the Moon.

1. By *Precept* the 4th, find the Sun's true Place, to the given Time.

2. In the Tables of the mean Motions of the Moon, write out her Longitude, Anomaly, and Node; to the Year, Month, Day, Hour, Minutes, and Seconds given, add the Motions of Longitude and of Anomaly into two several Sums; but the Node (because it is Retrograde) must be subtracted; that is, subtract the Motions of Days, Hours, Minutes, and Seconds, from

from the mean Motion answering the given Year; and thus you will have the middle Motions of the Moon collected to the given Time.

3. With the mean Anomaly enter the Table of the Moon's Elliptic Equation, in *Pages* 51, 52, and 53; and take out the Equation and Logarithm of her Distance from the Earth, (as I have shewn in that of the *Sun*) taking the proportional Parts to the Minutes and Seconds of her mean Anomaly; and (according to the Title of the Table) the Equation added to, or subtracted from the mean Longitude and Anomaly, gives her Place first Equated.

4. From the first Equated Place of the Moon, subtract the Sun's true Place; the Residue is the Distance of the Moon from the Sun; which double, and with the double Distance enter the Table, *Pages* 54, 55, and take out the Moon's Reflection, which (according to its Title) apply to the Equated Anomaly, and it gives you her Anomaly corrected. Also with the Distance of the Moon from the Sun take out of the same Table the Logarithm of the *Chord of Evection*: Or, to the Logarithm of the Diameter of the *Circle of Evection* 3.640432; add the Sine of the Distance of the Moon from the Sun, rejecting Radius, is the Logarithm of the *Chord of Evection*; which reserve.

5. To find the Synodical Anomaly; the Moon passing from the Conjunction or Opposition of the Sun to the Quadratures, the Complement of the Distance of the Sun and Moon to a Quadrant is to be added to the Correct Anomaly before found. But from the Quadratures to the Conjunction or Opposition, the Excess of the Distance of the Moon from the Sun above a Quadrant, is to be subtracted from the Correct Anomaly; and the Sum or Difference is the Synodical Anomaly.

6. From the Longitude of the Distance of the Moon from the Earth, (found by the 3d hereof) subtract the Logarithm of the *Chord of Evection*; and to the Residue add the Radius, the Sum is the Tangent of an Arch; from which reject 45°. Then say,

As Radius,
To the Tangent of the remaining Arch;
So is the Tangent of the half Synodical Anomaly.
To the Tangent of an Arch, whose Difference from the half Synodical Anomaly is the *Angle of Evection*; which, if the Synodical Anomaly were less than six Signs, it subtracts; if more, it adds.

7. If the Reflection, and Evection, both add, or both subtract their Sum; otherwise their Difference according to the greater

greater part, is the second Equation; which added to, or subtracted from the Longitude of the Moon first Equated, gives her Longitude in her Orb.

8. To find the Moon's Latitude, and Reduction from her Orbit to the Ecliptic.

1. With the double Distance of the Moon from the Sun, enter the Table, *Page* 56, and there take out the Equation of the Moon's Nodes; which, (according to its Title) added to, or subtracted from the equal Place of the Node, gives the true Place; which subtracted from the Moon's Longitude in her Orb, leaves the Argument of Latitude.

2. With the Distance of the Moon from the Sun, take out the Excess of the Moon's Latitude above 5 Degrees, in *Page* 57; which added to 5 Degrees (always) gives the Angle of the Moon's Orb and Ecliptic at that time.

Then for her Latitude, by Trigonometry, it will always hold.

As Radius,
To Sine Moon's Distance from the nearest Node;
So Sine of the Angle of her Orb with Ecliptic at that time,
To the Sine of her Latitude. Which is North, if Argument of Latitude be less than 6 Signs; but South, if more.

3. With the Argument of Latitude enter the Table, *Pages* 58 and 59, and take out the Reduction; (according to its Title) being apply'd to the Moon's Orbit-place, gives her Longitude reduced to the Ecliptic.

Example.

Example. *Anno* 1740, Let the Place of the Moon in Longitude and Latitude be required *April* 7th Day at Noon?

For the Moon's Latitude, and Ecliptic Place.

With the Distance of the Moon from the Sun 8 S. 20 Deg. 18 Minutes 33, enter the Table, *Page* 57, and you will find Angle of the Moon's Orb above 5 Degrees to be 17 Minutes 6 Seconds; which, added to 5 Degrees, make 5 Degrees 17 Minutes 6 Seconds the Obliquity of the Moon's Orb at that time, and the Moon's Orbit Place 9 S. 18 Degrees 24 Minutes 19 Seconds, which subtract from Place of the South Node 9 S. 17 Degrees 19 Minutes 32 Seconds, leaves 1 Degree 4 Minutes 47 Seconds, the Moon's Distance from the nearest Node.

These things being known, say,

	Deg.	*Min.*	*Sec.*	
As Radius	90	00	00	10.0000000
To S. ☽ from ☋	1	4	47	8.2751549
So S. Obliquity	5	17	6	8.9643061
To S. Latitude S. A.	0	5	58	7.2394610

For

For the Ecliptic Place.

With the Argument of Latitude 6 *S.* 1 *Degree* 4 *Minutes* 47 *Seconds*, enter the Table, *Page* 58, and take out the Reduction 15 *Seconds*; which (according to its Title) subtract from the Moon's Orbit Place 9 *S.* 18 *Degrees* 24 *Minutes* 19 *Seconds*, gives her Ecliptic Place 9 *S.* 18 *Degrees* 24 *Minutes* 4 *Seconds*.

Example 2. Let the Moon's Place be sought on *August* 29, at 2 *Minutes* past 4 o'Clock in the Morning, *Anno* 1741?

Equal Time.	Long. ☽				Anom. ☽				Node ☽			
	S.	°	′	″	S.	°	′	″	S.	°	′	″
Anno 1741	7	12	28	10	1	26	27	40	3	3	42	50
Aug. 28 Biss.	9	12	20	5	8	15	35	48		12	42	34
Hours 16		8	47	3		8	42	36			2	7
Minutes 2			1	6			1	5		12	44	41
Mean Mot.	5	3	36	24	10	20	47	09	2	20	58	9
Equat. add		3	2	09		3	2	09	Add		35	12
☉ Equated	5	6	38	33	10	23	49	18	2	21	33	21
☉ Place sub.	5	16	26	29	*Ref. sub.*		12	36	*Log. Di. Cir. E.* 3.640432			
Dist. ☽ à ☉	11	20	12	8	10	23	36	42	S. ☽ à ☉ 9°47′52″ 9.230886			
Double	11	10	24	16	2	20	12	8	Log. Ch. Ev. 2.871318			
									Log. ☽ à ⊖ 5.023790			
2d Equ. sub.		0	0	17	8	3	24	34	t. 89°35′5″ 12.152472			
☽ in her Orb	5	6	38	16	4	1	42	17	t. 45 0 0 subt.			
N. Node sub.	2	21	33	21	1	28	17	45	t. 44 35 5 9.9937043			
Argu. Lat.	2	15	4	55					t. 58 17 43 10 2092038			
Tr. Lat. ☽ N. A.		4	57	46					t. 57 55 24 10 2029081			
									Ev. 0 12 19 add			
Reduct. sub.			3	17					Re. 0 12 36 sub.			
Eclip. Place	5	6	34	59					2 d Eq 0 0 17 sub.			

For the Moon's Latitude and Ecliptic Place.

With the Distance of the Moon from the Sun 11 *S.* 20 *Deg.* 12 *Minutes* 8 *Seconds*, enter the Table, *Page* 57, and it gives the Angle of the Moon's Orb with the Ecliptic above 5 *Degrees* 27 *Seconds*; which added to 5 *Degrees* makes 5 *Degrees* 0 *Minutes* 27 *Seconds*, the Obliquity of the Moon's Orb at that Time. And the Place of the South Node 8 *S.* 21 *Degree* 31 *Minutes* 21 *Seconds* subtracted from the Moon's

Orbit-

Orbit-place 5 S. 6 Degr. 34 Min. 59 Seconds, leaves 2 S. 15 Deg. 4 Min. 55 Sec. the Moon's Distance from the nearest Node.

Now for the Latitude, say,

	Deg.	*Min.*	*Sec.*	
As Radius	90	00	00	—10.0000000
To S. of Dist. ☽ á ☊	75	4	55	— 9.9871097
So S. Obliquity of her Orb	5	0	27	— 8.9499447
To S. Latitude N. A.	4	57	46	— 8.9370534

Lastly, *For the Ecliptic-place.*

With the Argument of Latitude 2 S. 15 Degrees 4 Minutes 55 Seconds enter the Table, *Page* 59, and take out the Reduction 3 Minutes 17 Seconds, which (according to its Title) subtracted from the Moon's Place in her Orbit 5 S. 6 Degrees 38 Min. 16 Seconds, leaves 5 S. 6 Degrees 34 Minutes 59 Seconds, the Moon's Place reduced to the Ecliptic.

PRECEPT VII.

To find the true Time of the Conjunction or Opposition of the Sun and Moon.

This may be performed three several ways.

1. By the Logistical Logarithm.
2. By the Table of *Lunar* Aspects in *Page* 67.
3. By the Table of the mean Hourly Motion of the Moon from the Sun in *Page* 65; which Method is this.

With the Epact for the given Year, find the Day of the New or Full Moon, as has been shewn in *Page* 297; to which Day at Noon compute the true Place of the Sun, and the first Equated Place of the Moon. If these two Places be the same Sign, Degree, Minute, and Second, then have you the true Time of the New Moon: Or if their Places differ just six Signs, then have you the true Time of the Full Moon: But if their Places differ at Noon (as most commonly they do) subtract the lesser Place from the greater, and with this Difference enter the Table, *Page* 65, and see how many Hours and Minutes, or Minutes and Seconds of Time

the Distance of the Sun and Moon answers to; which, if the Sun's Place at Noon was more than the Moon's first Equated Place, then this Difference in Time must be added to the Day at Noon above found by the Epact; but if the Moon's Place exceeds the Sun's, then are the Luminaries past the Conjunction or Opposition: Therefore you must subtract the Time found in the Table from the Noon of that Day; and this Sum or Difference, is the supposed Time of the New or Full Moon; to which Time compute again the Sun's true Place, and the first Equated Place of the Moon; and if their Places now agree, then you may conclude you have the true Time of the New or Full Moon; but if you find a difference in their Places, you must enter the aforesaid Table, and take out the Time answering to that Difference, and add or subtract it, to, or from the time last found, according as the Moon's Place was less or more than the Sun's: And thus you may proceed until you find the Sun's Place, and the first Equated Place of the Moon to agree in Signs, Degrees, Minutes, and Seconds; for then you may be assured that you have the true equal Time of the New or Full Moon: And ever remember to make a Repetition of your Work until you find a Concurrence in the Places of the Sun and Moon: Here you are to Note, that the time of the New and Full Moons are more easily obtained than the Times of the Sextile, Square or Trine; by reason that several Inequalities of the Moon then vanish: An Example will make all plain to the diligent Reader.

Example. Let it be required to find the time of the Full Moon in *January*, *Anno* 1730?

OPE-

OPERATION.

Epact for the Year is 22, sub. from 45.
Rests 23d Day.

		Deg.	Min.	Sec.
Jan. 23, at Noon	☉ ♒	14	30	31
	☽ ♌	18	14	21
Difference past ☍		3	43	50
In the Table give 7 Hor.		3	33	20
Remain			10	30
Minutes 20 sub.			10	10
Remain				20
Seconds 40 sub.				20

	Ho.	Min.	Sec.
From the 23d.	0	00	00
Sub.	7	20	40

Remain 22 16 39 20 then

		Deg.	Min.	Sec.
	☉ ♒	14	11	51
	☽ ♌	14	21	08
Difference past ☍			9	17
Minutes 18 sub.			9	9
Remain				8
Seconds 16 sub.				8
Remain				0

	D.	H.	M.	S.
From *January*	22	16	39	20
Subtract			18	16
Remain	22	16	21	4

			Deg.	Min.	Sec.
At which time the	☉	♒	14	11	06
	☽	♌	14	12	17
Difference past ☍				1	11
Minutes 2 sub.				1	01
Remain					10
Seconds					10
					0

	D.	H.	M.	S.
From *January*	22	16	21	4
Sub.			2	20
Remain	22	16	18	44

			Deg.	Min.	Sec.
At which time the	☉	♒	14	11	0
	☽	♌	14	11	3
Difference past ☍					3
Seconds 6 sub.					3
Remain					0

So that the precise Time of this Full Moon is *January* 22 Days 16 Hours 18 Minutes 38 Seconds; at which time the Sun's true Place is ♒ 14 Degrees 11 Minutes, and the Moon in ♌ 14 Degrees 11 Minutes. After this manner must you find the equal Times of the New and Full Moons. This is the most expeditious of all other Methods made use of by Astronomical Writers; which Method is my own, and will become easy if you will but work upon your Slate, and find the proportional Parts of the Elliptic Equations by a Sliding-rule, as mentioned in *Page* 317.

PRE-

PRECEPT VIII.

To calculate the true Heliocentric, and Geometric Places of the five Primary Planets ♄, ♃, ♂, ♀, *and* ☿.

1. By Precept 4, find the Sun's true Place, and the Logarithm of his Distance from the Earth to the given Time.

2. Out of the Tables of the middle Motions of the Planet, write out the Longitude, Anomaly, and Node, to the Year, Month, Day, Hour, Minute, and Second; if need be, add them up severally; so have you the Mean Motions of the Planet to the Time proposed.

3. With the Mean Anomaly take out the Elliptic Equation of the Planet and the Logarithm, reserve the Logarithm of its Distance from the Sun in its Orbit, and apply the Equation to the Mean Longitude, (acording to its Title) either add or subtract, and the Sum or Difference will give you the Heliocentric place of the Planet in its Orbit from the Vernal Equinox.

4. From the Heliocentric Orbit-place, subtract the North Node of the Planet, and the residue is the Argument of Latitude; with which take out the Reduction of its proper Table, (and according to its Title) added to, or subtracted from the Heliocentric Orbit-place you will have the same Place reduced to the Ecliptic.

5. From the Longitude of the Sun, subtract the Heliocentric Ecliptic Longitude of *Saturn*, *Jupiter*, *Mars*; but from the Ecliptic Heliocentric Longitude of *Venus* or *Mercury* subtract the Longitude of the Sun; the residue is the Angle at the Sun, or Anomaly of Commutation; of which take the half; and if the half be more than three Signs, take its Complement to six Signs or 180 *Degrees*.

6. In the Table of Inclination of the Planet is the Curtation, which with the Argument of Latitude take out, and subtract from the Logarithm of its Distance from the Sun in its Orbit, give the Logarithm Curtated, or Logarithm from the Sun in the Ecliptic.

Or it may be found thus,

As Radius,

To the Logarithm of its Distance from the Sun in its Orbit.

So is the Co. Sine of the Planets Inclination, to the Logarithm Curtated. *Example*, in ☿,

As

	Deg.	Min.		
As Radius	90	00	0	—10.000000
To the Log. ☿ ☉ in Orb.				— 4.666826
So C. S. Inclination	1	57.	41	— 9.999746
To the Logar. Curtated				— 4.666572

7. From the Curtated Logarithm of *Saturn's Jupiter's Mars's* Distance from the Sun, subtract the Logarithm of the Sun's Distance from the Earth; to this Remainder add the Radius and you will have the Tangent of an Arch: from which reject 45°.

But in the two Inferiours *Venus* and *Mercury*, take the Logarithm of their Distance from the Sun, out of the Logarithm of the Sun's Distance from the Earth, and to the Remainder add Radius, and it is the Tangent of an Arch, from which reject 45 Degrees.

Then, As Radius,

To Tangent of the remaining Arch,

So is the Tangent of half Anomaly of Commutation, or its Complement, to the Tangent of an Arch. Whose Sum and Difference to the half Commutation is the Elongation and Parallax of the Earth's Orb. Or otherwise, the Parallax of the Earth's Orb may be found.

For the half Difference of any two Numbers, added to, and subtracted from their half Sum, gives the greater and lesser Numbers.

Thus, In *Saturn*, *Jupiter*, *Mars*, subtract the Logarithm of their Distance from the Sun, from the Logarithm of the Sun's Distance from the Earth (*i. e.* the greatest Logarithm from the lesser, the Radius being first added) and the Remainder will be the Tangent of an Arch; to which you must add 45°.

But in *Venus* and *Mercury* subtract the Logarithm of the Sun's Distance from the Earth, from the Logarithm of the Planet's Distance from the Sun, (the Radius being first added) and the Remainder is the Tangent of an Arch; to which always add 45°. Then,

As Radius,

To Co. Tangent of that Sum,

So is the Tangent of half Anomaly of Commutation, to the Tangent of an Arch.

This Paragraph is no more than the second Axiom (or *Norwood*'s 3d) of Plain Trigonometry; for here are always two Sides, and the Angle included given, to find the other two Angles; that is, the Distance from the Earth to the Sun, and

and the Distance of the Planet from the Sun by their Logarithms. with the Angle at the Sun always given, to find the Angle at the Earth, being the Elongation, and the Angle at the Planet, being the Parallax of the Orbit.

8. In *Saturn*, *Jupiter*, *Mars*, the fourth proportional Tangent added to the Anomaly of half the Angle at the Sun, or Commutation, gives the Elongation; but subtracted, gives the Parallax of the Earth's Orb.

But in *Venus* and *Mercury* the Sum of the fourth proportional Tangent added to half the Angle at the Sun, or Commutation, gives the Angle at the Planet or Parallax of the Orb; but subtracted, gives the Angle at the Earth, or Elongation from the Sun.

9. If the Anomaly of Commutation be less than six Signs, the Parallax of the Earth's Orb is to ~~be added~~ to the Heliocentric Longitude of *Saturn*, *Jupiter*, *Mars*; but in *Venus* and *Mercury* to be subtracted: If the Anomaly of Commutation be more than six Signs, the Parallax of the Earth's Orb (or the Angle at the Planet) is to be subtracted from the Heliocentric Longitude of *Saturn*, *Jupiter*, *Mars*; but in *Venus* and *Mercury* to be added; the Sum or Difference, is the true Geocentric Longitude from the Vernal Equinox.

Or, in *Saturn*, *Jupiter*, *Mars*, if the Anomaly of Commutation be less than six Signs, subtract the Elongation; but if more than six Signs, add the Elongation to the Sun's Place. In *Venus* and *Mercury*, if the Anomaly of Commutation be less than six Signs, add the Elongation; but if it be more, subtract, to or from the Sun's place; the Sum or Difference is the true Geocentric Longitude of the Planet as before.

10. For the Geocentric Latitude of the Planets.

With the Argument of Latitude take out of the proper Table the Planets Inclination, or Heliocentric Latitude; and then say,

As the Sine Commutation Co. Ar.
To S. of Elongation;
So is the Tangent of the Heliocentric Latitude,
To the Tangent of the Geocentric Latitude,
Or say,
As the Sine of Elongation Co. Ar.
To the Sine of the Commutation;
So Co. Tangent of the Heliocentric Latitude,
To Co. Tangent of the Geocentric Latitude.

Example

Example. Let the true Place of *Mercury* be enquired the ſeventeenth Day of *January* at Noon, *Anno* 1741, under the Meridian of our Table's equal Time?

See the Work:

Equal Time.	Long. ☿ S. ° ′ ″	Anom ☿ S. ° ′ ″	Node ☿ S. ° ′ ″
Anno 1741,	5 16 32 18	9 3 12 57	1·15 21 30
January 17,	2 9 34 14	2 9 34 12	2
Mean Mot.	7 26 6 32	11 12 47 9	1 15 21 32
Equat. add	5 35 20	L. ☿ à ☉ in Orb	4.666826
Hel. Or. pla.	8 1 41 52	Curtation ſub.	254
Node ſub.	1 15 21 32	L ☿ à ☉ in Ec.	4.666572
		Log. ☉ à ⊖	4.993606
Argu. Lat.	6 16 20 20	T. 25° 13′ 3″	9.672966
Reduct. ſub.	0 6 54	add 45 00 0	
Hel. Ecl. pla.	8 1 34 58	c.t. 70 13 3	9.5559039
Sun's Place	10 8 45 53	t. 33 35 13	9.8222139
Anom.Com.	9 22 49 35	t. 13 25 59	9.3781178
Half	4 26 24 47	S. 47 1 12	Parallax add,
Complement	1 3 35 13	Biſ. 20 9 14	Elongation ſub. from
Parallax add	1 17 1 12		the Sun's Place will
Geo. Place	9 18 36 10		give the Geocentric
	Direct Orient.		Place of *Mercury*.

For the Latitude.

With the Argument of Latitude 6 *S.* 16 *Degrees* 20 *Minutes* 20 *Seconds*, take the Inclination out of its proper Table 1 *Degree* 57 *Minutes* 41 *Seconds*, N. D. and then ſay,

	Deg.	*Min.*	*Sec.*	
As S. Commutation Co. Ar.	67	10	25	0.0354177
To S. Elongation	20	9	14	9.5372431
So T. of Inclination	1	57	41	8.5346079
To T. Geocentric Latitude S. A.	0	44	00	8.1072682

N. B. In three Superiours ♄, ♃, ♂, if the Anomaly of Commutation be leſs than ſix Signs, they are Oriental; if more, Occidental. But in the two Inferiours ♀ and ☿, when

when the Anomaly of Commutation is less than 6 Signs they are Occident, if more Orient.

Example 2. *Anno* 1741, Let the Place of *Venus* be required *February* 14, at 9 at Night?

Equal Time.	Long. ♀ S. ° ' "	Anom. ♀ S. ° ' "	Node ♀ S. ° ' "
Anno 1741	6 17 37 47	8 10 27 42	2 14 19 4
Feb. 14	2 12 5 51	2 12 5 45	3
Hours 9	36 3	36 3	2 14 19 7
Mean Mot.	9 0 19 41	10 23 9 30	
Equat. add	0 28 35	L. ♀ à ☉ in Orb	4.861765
Hel.Orb Pla.	9 0 48 16	Curtation sub.	61
Node sub.	2 14 19 7	L. ♀ à ☉ in Ecl.	4.861704
Argu. Lat.	6 16 29 9	Log. ☉ à ⊖	4.996104
		t. 36 16 22	9.865600
Reduct. sub.	1 37	add 45 0 0	
Hel. Ecl. Pla.	9 0 46 39	c.t. 81 16 22	9.1861302
Sun's Place	11 7 24 25	t. 33 18 53	9.8177274
Anom. Com.	9 23 22 14	t. 5 45 40	9.0038576
Half	4 26 41 7	sum 39 4 33	Parallax add
Complement	1 3 18 53	diff. 27 33 13	Elongation sub.
Parallax add	1 9 4 33		
Geo. Place	10 9 51 12		
Direct	Orient.		

	Deg.	*Min.*	*Sec.*	
As S. Commutation Co. Ar.	66	37	46	0.0371769
To S. Elongation	27	32	13	9.6649431
So T. Inclination	00	57	38	8.2244253
To T. Geocentric Latitude S. A.	00	29	03	7.9265453

Example 3. Let the Place of *Mars* be sought *April* 29, at 9 in the Morning 1741?

Equal Time.	Long. ♂ S.	°	'	''	Anom. ♂ S.	°	'	''	Node ♂ S.	°	'	''	
Anno 1741	3	15	7	14	10	13	46	4	1	17	50	40	
April 28	2	1	49	25	2	1	49	2				12	
Hours 21			27	31			27	31	1	17	50	52	
Mean Mot.	5	17	16	10	0	16	2	37					
Equat. sub.		2	38	50	L. ♂ à ☉ in Orb.								5.220306
Hel. Orb Pla.	5	14	37	20	Curtation sub.								181
Node sub.	1	17	50	52	L. ♂ à ☉ in Ecl.								5.220125
					Log. ☉ à ⊖								5.004744
Argu. Lat.	3	26	46	28	t.	31	20	3					9.784619
Reduct. add				44	add	45	00	00					
Hel. Ecl. Pla.	5	14	38	4	c. t.	76	20	29					9.3856215
Sun's Place	1	19	40	20	t.	57	28	25					10.1954968
Anom. Com.	8	5	2	16	t.	20	51	55					9.5811185
Half	4	2	31	8	sum	78	20	47	Elongation add				
Complement	1	27	28	52	diff.	36	36	57	Parallax sub.				
Parallax sub.	1	6	36	57									
Geo. Place	4	8	1	7									
Direct	Occident.												

For the Latitude of Mars.

	Deg.	*Min.*	*Sec.*	
As S. Commutation Co. Ar.	65	2	16	0.0425709
To S. Elongation	78	20	47	9.9909543
So T. Inclination	1	39	7	8.4599909
To T. Geocentric Latitude N. D.	1	47	4	8.4935161

Example

Example 4. Let the Place of *Jupiter* be required *September* 8, at 15 past 10 in the Morning, *Anno* 1741?

Equal Time.	Long. ♃ S. ° ′ ″	Anom. ♃ S. ° ′ ″	Node ♃ S. ° ′ ″	
Anno 1741	3 1 44 29	8 21 21 29	3 8 8 20	
September 7	0 20 47 0	0 20 46 10	34	
Hours 22	4 34	4 34	3 8 8 54	
Minutes 15	3	3		
Mean Mot.	3 22 36 6	9 12 12 16		
Equat. add	5 19 29	L. ♃ à ☉ in Orb.		5.721428
Hel. Orb Pla.	3 27 55 35	Curtation sub.		13
Node sub.	3 8 8 54	L. ♃ à ☉ in Ecl.		5.721415
		Log. ☉ à ⊖		5.001405
Argu. Lat.	0 19 46 41	t. 10 47 17		9.279990
Reduct. sub.	19	add 45 0 0		
Hel. Ecl. Pla.	3 27 55 16	c.t. 55 47 17		9.8324476
Sun's Place	5 26 27 25	t. 29 16 4		9.7485249
Anom. Com.	1 28 32 9	t. 20 51 32		9.5809725
Half	29 16 4	sum 50 07 36	Elongation sub.	
Parallax add	8 24 32	diff. 8 24 32	Parallax add.	
Geo. Place	4 6 19 48			
Direct and	Oriental.			

	Deg.	*Min.*	*Sec.*	
As S. Commutation Co. Ar.	58	32	9	0.0690679
To S. Elongation	50	07	36	9.8850578
So T. Inclination	20	27	8	7.8972048
To T. Geocentric Latitude N. A.	00	24	25	7.8513295

Example 5. Let the Place of ♄ be sought *November* 12 at 40ʹ 20ʹʹ past 9 in the Morning 1741?

Equal Time.	Long. ♄ S.	°	ʹ	ʹʹ	Anom ♄ S.	°	ʹ	ʹʹ	Node ♄ S.	°	ʹ	ʹʹ
Anno 1741,	4	0	44	17	7	1	16	17	3	21	17	24
Novem. 11,	0	10	31	54	0	10	31	43				15
Hours 21			1	46			1	46	3	21	17	39
Minutes 40				3				3				
Seconds 20												
Mean Mot.	4	11	19	0	7	11	49	49				
Equat. add		4	35	42	L. ♄ à ☉ inOrb							5.961401
Hel. Or. pla.	4	15	55	42	Curtation sub.							72
Node sub.	3	21	17	39	L ♄ à ☉ in Ec.							5.961329
Argu. Lat.	0	24	37	3	Log. ☉ à ⊖							4.994062
Reduct. sub.			1	15	c.t.	6	9	16				9.032733
					add	45	0	0				
Hel. Ecl. pla	4	15	53	27	c.t.	51	9	16				9.9059741
Sun's Place	8	1	14	27	t.	52	40	30				10.1177683
Anom.Com.	3	15	21	00	t.	46	33	55				10.0237424
Half	1	22	40	30	sum	99	14	25	Elongation sub.			
Parallax add		6	6	35	diff.	6	6	35	Parallax add.			
Geo. Place	4	22	0	2								
Direct and	Oriental.											

	Deg.	*Min.*	*Sec.*
As S. Commutation Co. Ar.	74	39	0—0.0157758
To S. Elongation	80	45	35—9.9943276
So T. Inclination	1	2	35—8.2602193
To T. Geocentric Latitude N. A.	1	4	3—8.2703227

PRE-

PRECEPT IX.

Shewing how to find the Time when any of the Primary Planets will be in their Aphelions and Perihelions.

Firſt, You muſt underſtand, that when the mean Anomaly of a Planet is no Signs, Degrees, Minutes, nor Seconds, then that Planet is in Aphelion; and if it be juſt ſix Signs, then it is in Perihelion. Theſe things being known, ſubtract the mean Anomaly for the given Year from 12 Signs, and ſeek the Remainder in the Months of that Planet, and what Day you find it ſtand againſt, is the Day that that Planet is in its Aphelion.

2. Subtract the mean Anomaly for the given Year from ſix Signs, and ſeek the Remainder as before, and you will have the Day that it is in its Perihelion.

Example. Anno 1728, I would know the Days that *Mercury* will be in Aphelion and Perihelion?

OPERATION.

	Aphelion.					Perihelion.			
	S.	*Deg.*	*Min.*	*Sec.*		*S.*	*Deg.*	*Min.*	*Sec.*
From	12	00	00	00	and	6	00	00	00
Sub. Anom. for 1728	9	8	42	44		9	08	42	44
Remains	2	21	17	6	and	8	21	17	16

Firſt, I ſeek in the Months of the mean Motions of *Mercury*; and I find this Anomaly 2 S. 21° 17′ 16″ ſtand againſt theſe Days, *viz.*

January 10
April 17
July 14
October 10
} which are the Days that *Mercury* will be in Aphelion in the Year 1728.

Alſo

Also I seek the Anomaly 8 S. 21° 17′ 16″ as above, and I find it against these Days,

viz. { *March* 4, *May* 31, *Aug.* 27, *Nov.* 23 } the Days on which *Mercury* will be in Perihelion *Anno* 1728.

Example. In *Venus*, *Anno* 1728?

OPERATION.

	Aphelion.					Perihelion.			
	S.	*Deg.*	*Min.*	*Sec.*		*S.*	*Deg.*	*Min.*	*Sec.*
From	12	00	00	00	and	6	00	00	00
Sub. Anom. for 1728	6	21	58	7		6	21	58	7
Remains	5	8	1	53	and	11	8	1	53

Anno 1728 { *April* 8, *Novem.* 18 } Aphelion. *July* 29, in Perihelion.

So *Venus* in the Year 1728, comes twice to her Aphelion, and once to her Perihelion, as above.

Example in *Mars*, *Anno* 1728?

	Aphelion.					Perihelion.			
	S.	*Deg.*	*Min.*	*Sec.*		*S.*	*Deg.*	*Min.*	*Sec.*
From	12	00	00	00	and	6	00	00	00
Sub. Anom. for 1728	11	15	12	21		11	15	12	21
Remain	00	14	47	39		6	14	47	39

Aphelion *Jan.* 28. But doth not reach his Perihelion till *Jan.* 1729. For the Anomaly 6 S. 14° 47′ 39″ is not to be found in the Months of the mean Motions of this Planet.

Example

Example in *Jupiter* for 1728.

	Aphelion.					Perihelion.			
	S.	*Deg.*	*Min.*	*Sec.*		*S.*	*Deg.*	*Min.*	*Sec.*
From	12	0	0	0	and	6	0	0	0
Sub. Anom. for 1728	7	16	48	53		7	16	48	58
Remains	4	13	11	7	and	10	13	11	7

These Numbers cannot be found in the Months of the mean Motions of *Jupiter*; which proves he doth not come to either of those Points in the Year 1728.

Example in *Saturn* for 1728.

	Aphelion.					Perihelion.			
	S.	*Deg.*	*Min.*	*Sec.*		*S.*	*Deg.*	*Min.*	*Sec.*
From	12	0	0	0	and	6	0	0	0
Sub. Anom. for 1728	1	22	31	56		1	22	31	56
Remains	10	7	28	4	and	4	7	28	4

These Anomalies cannot be found in the Months of the mean Motions of *Saturn*; which shews, he doth not come to those Points in the Year 1728. And thus I have given you a New and Expeditious Method to find the Days when the Planets will be in Aphelion and Perihelion. The Times of the Earth's Aphelion and Perihelion are found the same way.

Example in the *Earth* for the Year 1728.

	Aphelion.					Perihelon.			
	S.	*Deg.*	*Min.*	*Sec.*		*S.*	*Deg.*	*Min.*	*Sec.*
From	12	0	0	0	and	6	0	0	0
Sub. Anom. for 1728	6	11	58	52		6	11	58	52
Remain	5	18	1	8	and	11	18	1	8

The

The Anomaly 5 S. 18° 1′ 8″ answers to *June* 18, on which Day the Earth is in Aphelion: And the Anomaly 11 S. 18° 1′ 8″ I find the nearest unto it right against *December* 18, that Day that the Earth is in Perihelion. But to find the precise Time of the Aphelion and Perihelion, you must work as in the Solar Ingresses; thus, for the Time of the Earth's Aphelion.

	S.	*Deg.*	*Min.*	*Sec.*		
From	5	18	1	8		
June 18, sub.	5	17	33	8 Bissextile.		
Rem.			28	0		
Hours 11 sub.			27	6		
Rem.				54	*Thirds.*	
Minutes 21 sub.				51	45	
Rem.					2	15
Seconds 55 sub.					2	15
Rem.						0

By which it appears that the Earth will be in Aphelion, *Anno* 1728, *June* 18d. 11 h. 21′ 55″ P. M.

For the Time of its Perihelion.

	S.	*Deg.*	*Min.*	*Sec.*	
From	11	18	1	8	
, sub.	11	17	54	58	
Rem.			6	13	
rs 2 sub.			4	56	
Rem.			1	14	*Thirds.*
utes 30 sub.			1	13	55
Rem.					5
nds 2 sub.					5
Rem.					0

Anno

Anno 1728, *December* 18 D. 2 H. 30ʹ 2ʺ the Earth is in Perihelion.

For Proof of your Work, if to those times above found you Collect the Anomaly of the Earth, you will find it in the Aphelion to be nothing, and in the Perihelion six Signs. And after the same manner you may find the precise Times of the Perihelions and Aphelions of the Primary Planets.

PRECEPT X.

To find the Times of the Apogeon and Perigeon of the Sun and Moon.

The Method for this is the very same as has been shewn in the last *Precept*; but here you are to Note, that when I mention the Earth's or Sun's Anomaly, it is all one and the same thing; for 6 S. 11 Degr. 58 Min. 52 Seconds is the Earth's Anomaly as well as the Sun's for the Year of Christ 1728, Current; and that the Time of the Earth's Aphelion is also the time of the Sun's Apogeon; and the time of the Earth's Perihelion, is likewise the time of the Sun's Perigeon, which were found in the last *Precept*, and so needs not be repeated here: But the Places of the Earth and Sun are ever Diametrically opposite.

Secondly, Because of the Moon's swift Motion, she transits the Points of the Apogeon, and Perigeon several times every Year; therefore let it suffice to find the true Time of her transiting her Apogeon in *January* in the Year 1728.

OPERATION.

	S.	Deg.	Min.	Sec.
From	12	0	0	0
Sub. mean Anomaly 1728.	9	20	50	15
Rem.	2	9	9	45
Jan. 5, sub.	2	5	19	30
Rem.		3	50	15
Hours 7 sub.		3	48	38
Rem.			1	37
Minutes 1 sub.			1	5
Rem.				32
Seconds 59 sub.				32
Rem.				0

So the Moon is in Apogeon 1728, *Jan.* 5th, 7 H. 2 Min. 59 Sec. And in ♓ 27 Deg. 31 Min. 9 Seconds.

For the Time of her next Perigeon.

	S.	Deg.	Min.	Sec.
From	6	00	00	00
Sub, Anomaly for 1728	9	20	50	15
Rem.	8	9	9	45
Jan. 19, sub.	8	8	14	5
Rem.			55	40
Hour 1 sub.			32	39
Rem.			23	1
Minutes 42 sub.			22	52
Rem.				9
Seconds 17 sub.				9
Rem.				0

So

So that the Moon is in Perigeon *January* 19th 1 H. 42′ 17″, 1728, in ♍ 29 Degr. 3 Min. 15 Sec. And thus you may find in every Month of the Year the equal Time that the Moon is in Apogeon, and in Perigeon: For when you have subtracted the mean Anomaly for the Year from 12, and 6 Signs severally, those Remainders may be found in every Month of the Year, which has been taught above. You will have the times of the Moon's transiting those two Points in her System.

		D.	H.	M.	S.	
Anno 1728 ☽ in Apogeon.	*Jan*	5	7	2	59	☽ in ♓ 27° 31 min. 9 sec.
	Feb.	1	20	21	31	
	Feb.	28	9	40	8	
	March	27	22	58	32	
	April	24	12	17	17	
	May	22	1	35	50	
	June	18	14	54	24	
	July	16	4	12	57	
	Aug.	12	17	31	32	
	Sept.	9	6	50	6	
	Octob.	6	20	8	43	
	Novem.	3	9	27	15	
	Novem.	30	22	45	48	
	Decem.	28	12	4	19	☽ in ♉ 7° 25 min. 33 sec.

		D.	H.	M.	S.	
Anno 1728 ☽ in Perigeon	*Jan.*	19	1	42	17	☽ in ♍ 29° 3 min. 15 sec.
	Feb.	15	15	00	52	
	March	14	4	19	24	
	April	10	17	37	56	
	May	8	6	58	22	
	June	4	20	15	8	
	July	2	9	33	40	
	July	29	22	52	15	
	Aug.	26	12	9	19	
	Septem.	23	3	19	35	
	Octob.	20	14	47	58	
	Novem.	17	4	6	32	
	Decem.	14	17	25	2	☽ in ♏ 5° 53 min. 28 sec.

And as I have given you here the Moon's mean Place a the first and last times that she is in Apogeon and Perigeo in the Year 1728; so you may find her Place at the othe times, as set down, if you do but collect her mean Motion to those times severally.

PRECEPT XI.

To find the Time of the Retrogradations of the Planets.

What I intend here, is to find out the Days when the Planets become Retrograde; and first, you are to understand, that *Saturn* and *Jupiter* are Retrograde every Year; *Mars* once in two Years; *Venus* is six times Retrograde in the space of eight Years; *Mercury* three or four times every Year. In order therefore to make the Work plain and easie, we must have the Angle at the Sun, or Anomaly of Commutation when the Planet becomes Retrograde; and although 'tis impossible (by Reason of the different Positions of the Earth at different times) to fix this Angle to each Planet so as to be Perpetual; yet that it may be of Service herein, I have stated that Angle to each Planet, as is here set down.

If the Angle at the ☉ in		S. D. M. *Ret. Limit.*		S. D. M. *Dir. Limit.*	
♄	be more than	3 24 00	or less than	8 6 0	the Planet is Retrograde.
♃		4 6 30		7 23 30	
♂		5 8 0		6 22 0	
♀		5 15 0		6 15 0	
☿		4 28 0		7 2 0	

RULE. Subtract the mean Longitude of a superiour Planet for any given Year from the mean Longitude of the Sun for the same Year, and that is the mean Anomaly of Commutation; which, if it be not between the Retrograde and direct Limit, (as specified by the Table above) then the Planet is direct: And to find when it will become Retrograde, subtract the Angle at the Sun so found from the Retrograde Limit, and seek the Remainder in the Month of the Solar Tables for all the Planets except *Mercury*, and see what Day it answers to; on which Day compute the Longitude

Longitude of the Sun, and Heliocentric Place of the Planet; find the Angle at the Sun now; and if it be short of the Retrograde Limit, subtract it from it, and seek the Remainder in the Solar Tables, and add this time to the time first found in the Solar Tables; to this time compute the Places of the Sun and Planet as before, and the Angle at the Sun; and if it is yet short of the Retrograde Limit, subtract it from it, and work as before, till you find it agree with the Retrograde Limit, and then you will have the time that the Planet becomes Retrograde.

Example. In the Year 1727, I would know when *Saturn* becomes Retrograde?

OPERATION.

		S.	*Deg.*	*Min.*	*Sec.*	
1727 Mean Long. of	☉	9	20	26	3	
	♄	10	9	29	14	Subt.
Angle at the Sun		11	10	56	49	
Retrograde Limit		3	24	30	0	
In the Solar Tables		4	13	33	11	is *May* 15.
May 15	☉	2	4	35	3	
	♄ Heliocentr.	10	9	39	44	
Angle at the Sun		3	24	55	19.	This agreeing

with the Limit, shews *Saturn* becomes Retrograde *May* 15.

And if to this Point you add a Year and 12 Days, it will give *May* 27, 1728, the Day that *Saturn* becomes Retrograde. See the Table in my *System of the Planets Demonstrated*, Page 102.

Example in *Mercury*,

		S.	*Deg.*	*Min.*	*Sec.*	
1728 Mean Long. of	☿	5	21	50	41	
	☉	9	20	11	43	
Angle at Sun		8	1	38	58.	This being more

than the Direct Limit, shews the Planet to be Direct.

Retrograde

	S.	Deg.	Min.	
Retrograde Limit	4	28	0	
Angle at Sun sub.	8	1	39	
In ☿ Tables	8	26	21	is *March* 5.

	S.	Deg.	Min.	Sec.
March 5, ☿	2	20	26	57
March 5, ☉	11	26	9	37
Angle at Sun	2	24	17	20
Limit Retrog.	4	28	00	00
Distance	2	3	42	40

give 15 Days in *Mercury's* Tables; added to *March* 5, give 20 of *March*, the Days that *Mercury* becomes Retrograde; to which add 125 Days (See the above-cited Book, *Page* 66,) and that Points out *July* 23, when *Mercury* becomes Retrograde again. He is now in *Virgo*; add 112 Days, and that points out *November* 12, when *Mercury* becomes Retrograde a third time in the Year 1728. And thus you may proceed in any other Planet; by adding the Distance of Days from one Retrogradation to another, you will nearly have the Day of the next Retrogradation of the same Planet; which Distances between each Retrogradation of all the Planets you have Tables of in my Book above-mentioned.

PRECEPT XII.

To find the Times of the Mutual and Lunar Aspects.

To perform this, you must first have the Motion of all the Planets computed to the Noon of several Days successively; as, for a Month, or for a Year, *&c.* And for the mutual Aspects, it doth suffice to find the Day only, because of their slow Motions; but because of the Moon's swift Motion, her Aspects with the other Planets are (or ought to be) computed to the precise Time.

Then having the Motions of all the Planets in readiness for a Month, begin with any two of them, and guide your Eye down their Columns, and see if you can find the same Degree

Degree and Minute of an Aspect-sign, for that is the Day of the Aspect. See the *Definitions* under the Word *Aspect*.

Example. This Year 1727, I look in the Month of *November*, and I compare the Places of the *Sun* and *Saturn* together, and find on the 22d Day the Sun's Place at Noon ♐ 10 Degr. 52 Min. *Saturn* ♒ 10 Degr. 36 Minutes; this being two Signs asunder, makes the Sextile-aspect; but the true Time was before Noon that Day; because the Sun, being the swifter Planet, is a few Minutes less than two Signs distant from *Saturn*. The true Time of this Aspect is found by the Logistical Logarithms, thus,

		Deg.	Min.	
Diur. Motion of	☉	1	00	
	♄	0	5	Distance 21 Day at Noon 44′
Diur. Motion of ☉ à ♄		0	55	

Now say,

	H.	Min.		
If	0	55	Co.Ar. L.L.	622
Give	24	00		3979
What	0	44		1347
Answer	19	12		4948

By which the true Time of the Aspect is 21 D. 19 H. 12 Minutes.

Also in the same Month, I compare the Places of the Sun and *Jupiter* together, and find on the 8th Day at Noon the Sun in *Scorpio* 26 Deg. 41 Minutes, and *Jupiter* in *Taurus* 26 Degrees 31 Minutes Retrograde; that is, a few Minutes in Motion past the Opposition.

		Deg.	Min.	
Diur. Motion of	☉	1	1	
	♃	0	8	add, because ♃ is Retrograde.

Diurnal Motion ☉ à ♃ 1 9 Distance at Noon 0 Degrees 59 Minutes; therefore the time of this Opposition in *November* 7 Days 20 Hours 30 Minutes: And after this manner I compare the Sun's Place with the other Planets; by which I discover all

all the Aspects that he makes with them. Then I take *Saturn*'s Place, and compare it with the Places of *Jupiter*, *Mars*, *Venus*, and *Mercury* severally; by which I shall discover all the Aspects that he makes with them. Then I compare the Place of *Jupiter* with *Mars*, *Venus* and *Mercury*, and his Aspects with them are discovered. Next, I compare the Place of *Mars* with the Places of *Venus* and *Mercury*; and Lastly, I compare the Places of *Venus* and *Mercury* together; and if they form any Aspects with each other, I shall discover the Day whereon they fall; and the Hour and Minute may be found by the Logistical Logarithms, as is shewn above; observing, if the Planets are both Direct, or both Retrograde, that you take the Difference between their Diurnal Motion; but if one be Direct, and the other Retrograde, the Sum, and this Sum or Difference, shall be the Diurnal Motion of the swifter Planet from the slower. And after the like manner must you examine each Month in the Year; by which Method, not one Mutual Aspect can escape your Inspection.

Secondly, *For the Lunar Aspects.*

Compare the Longitude of the Moon with every Planet severally, as has been shewn in the Primary Planets above, and you will discover the Days of the Lunar Aspects; the Hour and Minute may be had by the Tables of Lunar Aspects, *Page* 67, *&c.* by entring the Table with the Diurnal Motion of the Moon from the Planet; and the first Column on the Left-hand, with the Distance of the Moon and Planet on the Day at Noon before the Aspect, and the Angle, or Place of Meeting, is the Hour and Minute of the Time of the Aspect.

Example. Anno 1727, in *November*, I would know the time of the Conjunction of the Moon and *Jupiter*?

By comparing the Longitude of the Moon with that of *Jupiter* in the said Month, I find that some time between the 16th and 17th Day at Noon they will be Conjoin'd.

OPERATION.

		S.	°	′		S.	°	′
Place of ☽ { 17 } Day at Noon is	17	2	3	5	♄	1	25	19
	16	1	20	19		1	25	25
Diurnal Motion of ☽			12	46 of ♃				8
Add				8		(Retrog.		
Diurnal Motion ☽ à ♃			12	54				

		S.	*Deg.*	*Min.*
Place of ♃	16 Day at Noon	1	25	27
☽		1	20	19
Their Distance at Noon			5	8

By entering the Table of Lunar Aspects, with the Diurnal Motion of the Moon from *Jupiter*, and their Distance at Noon, as before directed, you will find the time of the Conjunction to be the 16 D. 9 H. 33 Minutes. And in a Conjunction of the Moon with the Planets, if you have regard to their Latitudes, you may discover whether there will be an Occultation or not. In the Example before us, the Latitude of the Moon is 4 Degr. 36 Min. North, and the Latitude of *Jupiter* 1 Degree 4 Minutes South; which added together, make 5 Degrees 43 Minutes, their Difference in Latitude; by which I see the Moon passes far above *Jupiter* at the Conjunction; and therefore free from Occultation. This Method is to be observed in the Moon and other Primary Planets, whether it be a Conjunction, Sextile, Square, Trine, or Opposition.

PRECEPT XIII.

Shewing how to Determine the Ecliptic Boundaries of the Sun and Moon.

First for the Moon.

OPERATION.

	Min.	*Sec.*
The Moon's Perigeon Horizontal Parallax	61	24
Sun's Horizontal Parallax add	00	10
Sum	61	34
Sun's Apogeon, apparent Semidiameter sub.	15	49
Greatest apparent Semidiameter Earth's Shadow	45	45
Moon's Perigeon Semidiameter add	16	40
Sum	62	25

In the Table of the Moon's Latitude, *Page* 58, the Argument of Latitude answering to this Latitude 62 Min. 25 Sec. is 12 Degrees 1 Minute 22 Seconds; that is, before and after 6 or 12 Signs. For if the Distance of the Moon from either Node at the time of the true Opposition to the Sun,

	S.			*S.*	
be less than great. Limit.	0 / 6	12° 1′ 22″,	or more than	5 / 11	17° 58′ 38″.

The Moon at that Full will be Eclipsed; else not. And if at the time of the Opposition of the Sun and Moon, the Latitude of the Moon exceed the Sum of the Semidiameters of the Moon's and Earth's Shadow, the Moon at that time will not be Eclipsed; but if less, she will. See the Word *Limit* in the *Definitions.* For the least Limit work thus.

Apog.

	Min.	*Sec.*
ogeon Horizontal Parallax Moon	54	59
n's add	0	10
Sum	55	59
n's Perigeon Semidiameter sub.	16	22
pparent Semidiameter Earth's Shadow	38	47
Ioon's Apogeon Semidiameter add	14	54
Sum	53	41.

The rgument of Latitude answering this Latitude 53 Minutes 1 Seconds, is 0 S. 10 Degrees 19 Minutes 17 Seconds: That , before and after six and twelve Signs.

Thus:

S.		S.	
0 6	10 deg. 19 min. 17 sec. or	5 11	19 deg. 40 min. 43 sec.

And the mean Limit is 0 S. 11 Deg. 5 Min. 4 Sec.

Thus:

S.		S.	
0 6	11 deg. 5 min. 4 sec. or	5 11	18 deg. 54 min. 56 sec.

Secondly, To determine the Ecliptic Boundaries of the Sun

		Min.	*Sec.*
Perigeon Horizontal Parallax of the Moon		61	24
Sun's sub.		0	10
Rem.		61	14
Perigeon Horizontal Semidiameter of	☉	16	22
	☽	16	40
Sum		94	16

In the Table of the Moon's Latitude, the Argument of Latitude answering to this Latitude 94 *Min.* 16 *Seconds*, is 18 *Degrees* 20 *Minutes* 8 *Seconds*; that is, before and after six and twelve Signs.

 Thus:

Thus,

S.			S.	
0 6	18° 20′ 8″	or	5 11	11° 39′ 52″ Greatest Limit.

For the least Limit.

	Min.	Sec.
Apogeon Horizontal Parallax of the ☽	54	59
Sun's sub.	00	10
Difference	54	49
Apogeon Semidiameter of ☉	15	49
Apogeon Semidiameter of ☽	14	54
Sum, = to ☽ Latitude	85	32

The Argument of Latitude answering to this Latitude 85 Minutes 32 Seconds, is 0 *S.* 16 Degrees 35 Minutes 5 Seconds the least Limit; that is, before and after six and twelve Signs.

Thus.

S.		S.	
0 6	16 deg. 35 min. 5 sec.	5 11	13 deg. 24 min. 55 sec. And

the mean Limit, that is, when the Luminaries are at a middle distance from the Earth, is 17 Degrees 21 Minutes 52 Seconds before six and twelve Signs.

Thus,

S.		S.	
0 6	17 deg. 21 min. 52 sec. or		12 deg. 38 min. 8 min. So that

when you are seeking an Eclipse of the Sun, you must make use of the Limit the Sun is nearest to; as, if he be in Apogeon, take the least Limit, *&c.*

And if at the true Time of the true Conjunction of the Sun and Moon, the Moon's true Longitude be less than the Sum of the apparent Semidiameters of the Sun and Moon, added to these Differences of the Horizontal Parallaxes, the Sun will then be Eclipsed somewhere on the Earth; else not.

Otherwise,

Otherwise, If at the apparent Time of the Visible Conjunction of Sun and Moon, the Visible Latitude of the Moon be less than the Sum of their apparent Semidiameters, then the Sun will be Eclipsed at that Time and Place on the Earth.

But if the Moon's Visible Latitude exceed that Sum, then will the People of that Place who behold the Moon's Visible Latitude to be such, see no Eclipse at all.

PRECEPT XIV.

To find in any Year, how many Eclipses there will be, and in what Months they happen.

First, You are to observe, that the Sun enters the twelve Zodiacal Signs on these Days, as hereunder set down.

January,	*February*,	*March*,	*April*,	*May*,	*June*,	*July*,	*August*,
9	7	9	9	10	10	12	12
♒	♓	♈	♉	♊	♋	♌	♍

September,	*October*,	*November*,	*December*.
12	12	11	10
♎	♏	♐	♑

2. Look into the Table of the Moon's mean Motion for the given Year, and see what the Radical Place of the Moon's North Node is; for in those Months in which the Sun enters the Signs that the Moon's Nodes are in, will the Eclipses of the Sun and Moon fall in that Year. And the Moon's Nodes being always Diametrically opposite, if there happen an Eclipse in *January*, there will also be one in *July*; because the Sun enters *Aquarius* in *January*, and *Leo* in *July*, *Aquarius* and *Leo* being opposite Signs, *&c.* And if the Nodes change their Signs in that Year in which you are seeking the Eclipses, then in the Months preceding the Months above found, will there also be an Eclipse; and these Months I call the *Node-Months*.

3. By *Precept* 7, find the equal Time of the New and Full Moons in the *Node-Months*, and also in the Months next before and after the *Node-Months*, (by which means you will be sure not to miss the Eclipses that Year.) Set down the true Places of the Luminaries at the New Moon, and the Place of the Moon at the Full; and from these Places severally subtract the Place of the Moon's North Node for the time given; and this Remainder is called the *Argument of the Moon's Latitude*; which,

if

if it be less than the Limits of Eclipses set down in the l
Precept, there will be an Eclipse at that time, else not.

Example. Let it be required to find how many Eclips there will be of the Sun and Moon in the Year of Christ 174 and also in what Month they happen?

The Method of your Examination for the whole Year wi stand thus:

The Year 1743, is the third past Leap-year; the Epac is 15; and the Radical Place of the Moon's North Node i *Taurus* 25 Degr. 3 Min. 24 Seconds. Consequently, th Months in which the Eclipses will happen, are *April*, *May*, *October*, and *November*. *Note*, Be sure to examine the Luna-tions in the Month before, and in the Month after the Nod Months.

	D.	*H.*	*M.*		*S.*	*D.*	*M.*	
Full ☽ 1743, *March*	28	11	44	☽ in	6	18	43	Short of the Bounds no Eclipse.
North Node sub.					1	20	25	
Argument Latitude					4	28	18	
Ecliptic Bounds ☽ are from					5	19	41	
To					6	10	19	

New ☽ 1743, *April*	12	21	43	in	1	3	45	Sun Ecl. Invisible because ☽ South Lat.
North Node sub.					1	19	37	
Argument Latitude					11	14	08	
Ecliptic Bounds ☉ are from					11	11	40	
To					0	18	20	

Full ☽ 1743, *April*	27	3	23	☽ in	7	17	32	Moon Ecl. Invisi. because she's under the Earth.
North Node sub.					1	18	52	
Argument Latitude					5	28	40	
Ecliptic Bounds ☽ are from					5	19	41	
To					6	10	19	

New ☽ 1743, *May*	12	5	56	in	2	2	4	Sun Ecl. Invisible at *London*.
North Node sub.					1	18	3	
Argument Latitude					0	14	1	
Ecliptic Bounds ☉ are from					11	11	40	
To					0	18	20	

Full

	D.	H.	M.		S.	M.	D.	
Full ☽ 1743, *May*	26	19	14	☽ in	8	15	59	Past the Bounds, no Eclipse.
North Node sub.					1	17	17	
Argument Latitude					6	28	42	
Ecliptic Bounds ☽ are from					5	19	41	
To					6	10	19	
Full ☽ 1743, *Septem.*	22	3.	40	☽ in	0	9	58	Short of the Bounds no Ecl.
North Node sub.					1	11	1	
Argument Latitude					10	28	57	
Ecliptic Bounds ☽ are from					11	17	59	
To					0	12	1	
New ☽ 1743, *October*	6	2	46	in	6	23	48	Sun is Eclipsed small, Invisible at *London.*
North Node sub.					1	10	17	
Argument Latitude					5	13	31	
Ecliptic Bounds ☉ are from					5	13	25	
To					6	16	35	
Full ☽ 1743, *October*	21	15	24	☽ in	1	9	20	Moon Ecl. Visible Great.
North Node sub.					1	9	27	
Argument Latitude					11	29	53	
Ecliptic Bounds ☽ are from					11	17	59	
To					0	12	1	
New ☽ 1743, *Novem.*	4	18	30	in	7	23	32	Sun is Ecl. Invisible at *London.*
North Node sub.					1	8	42	
Argument Latitude					6	14	50	
Ecliptic Bounds ☉ are from					5	13	25	
To					6	16	35	
Full ☽ 1743, *Novem.*	20	2	31	☽ in	2	9	4	Past the Bounds, no Eclipse.
North Node sub.					1	7	54	
Argument Latitude					1	1	10	
Ecliptic Bounds ☽ are from					11	17	59	
To					0	12	1	

By the Work above, I have examined all the New and Full Moons in the Year 1743, that are possible of producing an Eclipse; and I find within the Circumference thereof, there will

will be six Luminarian Eclipses, *viz.* four of the Sun and two of the Moon: And for this purpose also, I have Calculated the following Table; which, if you enter with the Moon's mean Anomaly at the time of any Eclipse, and take out the Argument of Latitude, and add it to the Argument of Latitude at the time of any Eclipse, that will shew you whether the next Lunation will produce an Eclipse or not: For if the Sum, be within the Limits of Eclipsing (as determin'd in the last *Precept*) there will be an Eclipse; else not.

A TABLE *of the Mean Motion of the Argument of Latitude of the Moon, for discovering of the Luminarian Eclipses.*

Mean Anom. ☽			*Argument Latitude.*			
S.	*Deg.*	*Signs*	*S.*	*Deg.*	*Min.*	*Sec.*
0	00	00	6	14	04	35
0	15	11	6	14	17	05
1	00	11	6	14	29	35
1	15	10	6	14	42	05
2	00	10	6	14	54	35
2	15	9	6	15	07	05
3	00	9	6	15	19	35
3	15	8	6	15	32	05
4	00	8	6	15	44	35
4	15	7	6	15	57	05
5	00	7	6	16	09	35
5	15	6	6	16	22	05
6	00	6	6	16	34	35

Example. I have found that the Sun is Eclipsed the 4th of *November* 1743: I would know at one View whether the next Full Moon, will be Eclipsed or not?

OPE-

OPERATION.

	S.	Deg.	Min.	Sec.
Moon's Mean Anomaly	10	7	59	17
Argum. Latitude *December* 28, is	6	14	50	0
Argument Latitude *per* Table	6	14	42	0
Argument Latitude	0	29	32	0

This Sum, is the Argument of Latitude at the Full Moon in *November* 1743; which far exceeding the greatest Limit of the Moon's Eclipse, proves that, that Full Moon will pass below the Earth's Shadow; and consequently free from any Obscurity.

Note, When the Argument of Latitude falls near the Limit, then you must carefully examine that Lunation as has been taught in *Precept* 13; otherwise 'tis possible you may miss of discovering a small Eclipse.

PRECEPT XV.

To Calculate an Eclipse of the Moon.

First, In order hereunto, you must set down the Calculation of the Sun's and Moon's Place to the equal Time of the true Orbit-opposition; and for an Example, I shall take the Moon's Eclipse which I have found in the last *Precept* to happen *December* 21, *Anno* 1740, the Time of the true Opposition found, as has been shewn in *Precept* 7, stands thus:

Eq. Time &c	Long. ☉ S ° ′ ″	Anom. ☽ S ° ′ ″	Equation. ′ ″	
Anno 1740	9 20 17 10	6 11 51 48	2 4	L L 14629
Dec. 21 Biff.	11 20 53 25	11 20 52 22	13 36	6446
Hours 11	27 6	27 6	0 28	21075
Minutes 56	2 18	2 18	6 13 add	
Second 38	2	2	6 41	
Mean Mot.	9 11 40 1	6 3 13 36		
Equat. add	0 6 41			
Sun's Place	9 11 46 42			

Eq. Time &c	Long. ☽ S ° ′ ″	Anom. ☽ S ° ′ ″	Node ☽ S ° ′ ″
Anno 1740	2 19 54 32	10 14 40 33	3 23 05 44
Dec. 21 Biff	0 10 47 47	11 1 08 09	0 18 51 09
Hours 11	6 2 21	5 59 17	1 27
Minutes 56	30 45	30 29	7
Seconds 38	21	21	—18 52 43
Mean Mot.	3 7 15 46	9 22 18 49	3 4 13 1
Equat. add	4 30 56		
☽ in her Orb	3 11 46 42		
Node sub.	3 4 13 1		
Argu. Lat.	0 7 33 41		
True Lat. N. A	39 26		
Reduct. sub.	1 42		
Ecl. Place	3 11 45 00		

1 With the mean Anomalies of the Sun and Moon, take out of the Table, *Page* 62, their Hourly Motion, thus:

	Min.	*Sec.*
Hourly Motion of ☉	2	33
Hourly Motion of ☽	31	57
Hourly Motion of ☽ à ☉	29	24

Now

Now for the Time of Reduction, say,

	Min.	*Sec.*	L L
As Hourly Motion of Moon from Sun	29	24	3098
To one Hour, or	60	00	0
So is Reduction	1	42	15477
To Time of Reduction	3	28	12379

This Time of Reduction thus found, (in any Eclipse) applied to the equal Time first found, according to its first Title, gives the equal Time of the middle of the Eclipse; and applied contrary to its first Title, gives the equal Time of the true Ecliptic Opposition. Thus, if the Latitude of the Moon be Ascending (either North or South) then the Time of Reduction must be subtracted from the equal Time of the true Orbit-opposition; and the Remainder is the equal Time of the middle of the Eclipse: Add the Time of Reduction to the equal Time of the Orbit-opposition, and the Sum is the equal Time of the true Ecliptic Opposition.

2. But when the Latitude of the Moon is Descending (See the Schemes, *Page* 61) which is when the Argument of Latitude is more than 3 or 9 Signs, and less than 6 or 12, add the Time of Reduction to the equal Time of the true Orbit-opposition, gives the middle of the Eclipse; and subtracted, you will have the true Time of the Ecliptic-opposition. Thus in the Eclipse before us;

	S.	*D.*	*M.*	*S.*
Equal Time of true Orbit ☍ at *London* 1740 *December*	21	11	56	38
Time of Reduction subtract and add			3	28
Equal Time of the middle	21	11	53	10
Equal Time of the Eclip. ☍		12	00	06
Equation of Time subtract			4	33
Apparent Time of the Middle	21	11	48	37
Apparent Time of the Ecliptic ☍		11	55	33

3. With the mean Anomalies of the Sun and Moon, take out the Horizontal Parallaxes (the Sun's being ever 10 Sec.) and apparent Semidiameters, and from the Sum of the Horizontal Parallaxes, subtract the apparent Semidiameter of the Sun; the Remainder will be the apparent Semidiameter of the Earth's Shadow that the Moon at that Time passeth through.

	Min.	Sec.
Horizon Parallax of ☉	0	10
Horizon Parallax of ☽	56	42
Sum	56	52
Semidiameter Sun subtract	16	22
Appar. Semi. Earth's Shadow	40	30
Semediameter Moon add	15	24
Sum	55	54
Moon's true Latitude subtract	39	26
Remain the Parts deficient	16	28

Hence, because the Parts deficient are less than the Moon's Diameter, it shews, the Eclipse will not be Total; but if they be equal, then the Eclipse will be Total without continuance. But if the Parts deficient be more than the Moon's Diameter, then the Eclipse will be Total with continuance.

Now for the Digits Eclipsed, say,

		Min.	Sec.	
As Semidiameter ☽		15	24	LL 5906
To six Digits	6	00	00	10000
So Parts deficient		16	28	5615
To Digits	6	24	55	9709

4. To find the Scruples of Incidence, or Motion of half Duration.

This may be performed four several Ways.

1. By the 47th of the first of *Euclid.*
2. By Trigonometry.
3. Logarithmetically.
4. By *Shakerley*'s Logistical Logarithms.

First, In the right angled plain Triangle A P M, right Angled at P, there are given in the following Scheme, A P the true Latitude of the Moon, at the Time of the true Opposition 39 Min. 26 Sec. and A M = A N the Sum of the Moon's

Moon's Semidiameter and Earth's Shadow 55 Min. 54 Sec. to find P M = P N the Motion of half Duration.

OPERATION.

	Min.	*Sec.*		*Min.*	*Sec.*
Latitude ☽	39	26	Sum Semidiam.	55	54
	60			60	

```
   2366            3354
   2366            3354
  ------          ------
  14196            13416
 14196            16770
 7098            10062
4732            10062
---------       ---------
5597956         11249316
                 5597956
                ---------
```

Extract the Square Root 5651360(2377 Sec.

which Divided by 60, gives 39 *Minutes* 37 *Seconds* = P M = P N, the Motion of half Duration.

Secondly, *By Trigonometry.*

1. For the Angles at A and M.

	Deg.	*Min.*	
As Sum Semidiameters A M	3354	—	3.525563
To Radius	90	00	10.000000
So Moon's Latitude A P	2366	—	3.374015
To C. ſ. Angle P A M	45	8	9.848452

Again:

	Deg.	*Min.*	
As Radius	90	00	10.000000
To Z Semid. Moon's and Earth's Shadow	3354	—	3.525563
So S. Angle P A M	45	8	9.850493
To P M Motion of half Duration	2377	—	3.376056

the ſame as before.

Thirdly,

Thirdly, *Logarithmetically.*

RULE. The Rect-angle made of the Sum, and Difference of any two Numbers, is equal to the Difference of the Squares of those Numbers. That is, take the Logarithms of the Sum and Difference of the Semidiameters of the Moon's and Earth's Shadow, and of the Latitude of the Moon; the half Sum of the two Logarithms is the Logarithm of the Scruples of Incidence or half Duration.

	Min.	*Sec.*		*Min.*	*Sec.*
☽ Latitude	39	26	Sum Semidiameter ☽ and ⊖	55	54
	60			60	
	2366		Seconds	3354	
	3354				

Sum 5720=3.757396
Difference 988=2.994757
Sum Logar. 6.752153
60) 2377 3.376076 half.
That is 39 *Minutes* 37 *Seconds.*

Lastly, *By* Shakerley's *Logistical Logarithm.*

RULE. Subtract the Logistical Logarithm of the Sum of the Semidiameters of the Moon's and Earth's Shadow, from the Logistical Logarithm of the Moon's Latitude, the Remainder is the Sine of an Arch; to the Co. Sine of which Arch, add the Logistical Logarithm of the Sum of the Moon's and Earth's Shadow; this Sum shall be the Logistical Logarithm of the Scruples of Incidence or half Duration.

OPE-

OPERATION.

		Min.	Sec.		
Latitude of the Moon		39	26	LL	9.81771
Sum of the Semid. ☽ and ⊕ Shadow		55	54	LL	9.96926
Remains the Sine of	44	52			9.84845
Co. Sine of	44	52			9.85049
Sum Semid. Moon and Earth Shad.		55	54	LL	9.95290
Scruples of Incidence as before		39	37		9.81975

5. To find the Time of Incidence, or half Duration, and from thence the Beginning and Ending of the Eclipse.

For the Time of half Duration.

By Street's *Logistical Logarithm, say,*

	Min.	Sec.		
As true Hourly Motion ☽ à ☉	29	24	LL	3098
To one Hour, or	60	00		0
So are Scruples of Incidence	39	37		1803
To the Time	80	51		1295

For the Beginning and End of the Eclipse.

		D.	H.	M.	S.
Apparent Time of the middle		21	11	48	37
Time of half Duration subtract and add			1	20	51
Appar. Time of	Beginning	21	10	27	46
	End	21	13	9	28

6. To find the Latitude of the Moon at the Beginning and End of the Eclipse.

The most exact Way is to Calculate the Place of the Moon in Longitude and Latitude by the 6th *Precept*. But because that is something troublesome, and the Use of her Latitude being for no other End than to serve for Drawing the Type,

&c

or a Representation of the Eclipse in *Plano*, therefore the following practical Method is sufficient for this Purpose.

First, Find the Motion of the Sun in Time of Incidence and add it to the Scruples of Incidence.

	Min.	*Sec.*	
As one Hour, or	60	00 LL	0
To Sun's Hourly Motion	2	33	13716
So Time Incidence	80	51	1295
To Mot. ☉ in that Time	3	26	12421
Scruples of Incidence add	39	37	
Sum	43	3	

subtract this Sum, from the Argument of Latitude at the middle, gives the Argument of Latitude at the Beginning; and added, gives the Argument of Latitude at the End; by which Arguments of Latitudes find the Moon's true Latitude answering thereunto by the Table, *Page* 58.

OPERATION.

	S.	*D.*	*M.*	*S.*
Argument Latitude middle	0	7	33	41
Sum sub. and add			43	3
Arg. Lat. { Beginning	0	6	50	38
Arg. Lat. { End	0	8	16	44

		Min.	*Sec.*	
Hence, the Lat. ☽ at	Beg.	35	42	North Ascending.
	End	43	8	

Note, The Latitude is Ascending either North or South, until the Moon be three Signs distant from her Nodes; because it increases all that Time; but if the Distance be more than three Signs, then 'tis Descending towards the Nodes, and therefore the Latitude decreases.

From

From the foregoing Calculation I have found the

		D.	H.	M.	S.	
Ap. Time at *London* of the	Begin. 1740, *Decem.*	21	10	27	46	PM
	Middle		11	48	37	PM
	Ecliptic ☍		11	55	33	PM
	End		13	9	28	PM
	Total Duration		2	41	42	
	Digits Eclipsed		6	24	55	

7. To delineate the Eclipse of the Moon in *Plano.*

1. From the Line of Lines on the Sector opened to any convenient Radius, (or from any Scale of equal Parts) take the Semidiameter of the Earth's Shadow in your Compasses, and set one Foot in A; describe the innermost Circle B E, this shall represent that part of the Cone of the Earth's Shadow

F

and Atmosphere 40 Minutes 30 Seconds, cut off in that Place which the Moon passeth thro' at that Time.

2. With the Sum of the Semidiameters of the Moon and Shadow 55 Minutes 54 Seconds taken from the same Scale, describe the outmost Circle, F, N, M, I: Draw F I, to represent a Horizontal Line and Ecliptic.

3. At the Time of the middle of the Eclipse find the Altitude of the Nonagesime Degree, which in this Eclipse at *London* is 61 Degrees 55 Minutes; then by help of the Lines of Chord on the Sector set off the Position of the Moon's Orb at that Time.

4. Take the Latitude of the Moon at the beginning of the Eclipse 35 Minutes 42 Seconds, from the Line of Lines on the Sector (set to the same Radius as you draw the Circles by) and set it from A to K, because the Latitude is North; (had it been South, you must have set from A towards D) take 43 Minutes 8 Seconds, the Latitude at the end, and set it from A to L; then by help of your Parallel-ruler draw K M, and N L, parallel to F I, and draw M N, which shall represent the Moon's Orb during the Time of the Eclipse, and shall lye in a true Position at that Time in respect of the Horizon of *London*.

Lastly, Divide M N into two equal Parts, at P, with the Semidiameter of the Moon 15 Minutes 24 Seconds, on M P and N; severally sweep three Circles; so shall that at M, represent the Moon at the beginning of the Eclipse, that at P at the middle or greatest Obscuration, and that at N, the Moon when she begins to Emerge out of the Earth's Shadow and Atmosphere, or the final End of the Eclipse. A P, is the Axis of the Moon's Way, to which she always comes at the middle of the Eclipse; A L is the Axis of the Ecliptic, to which she comes at the time of the true Ecliptic Opposition. And the Angle L A P, is the double Quantity of the Time of Reduction, as is manifest if you compare the Scheme with the Calculation.

N. B. For the Position of the Luminaries in Eclipses, observe that their Axis make nearly the Angle with the Horizon at *London* thus, *viz.*

In ♈ at their Rising near right: On the Meridian 60 *Degrees* to the Right-hand. At Setting about 45 *Degrees* to the Right-hand.

In ♉ at their rising near right: On the Meridian 64 *Degrees* to the Right-hand; at setting 50 *Degrees* to the Right-hand.

In

In ♊ at their rising near right: On the Meridian 70 *Degrees*; at setting 55 *Degrees* both to the Right-hand.

In ♋ at their rising about 87 *Degrees* to the Left-hand: On the Meridian right; at setting about 60 *Degrees* to the Right.

In ♌ at their rising about 60 *Degrees* to the Left: On the Meridian 80 *Degrees* to the Left; and at setting 54 *Degrees* to the Right.

In ♍ at their rising about 40 *Degrees* to the Left: On the Meridian 70 *Degrees* to the Left; and at setting 50 *Degrees* to the Right-hand.

In ♎ at their rising about 30 *Degrees* to the Left: On the Meridian 65 *Degrees* to the Left; and at setting 55 *Degrees* to the Right-hand.

In ♏ at their rising 42 *Degrees* to the Left: On the Meridian 80 *Degrees* to the Left; and at setting 70 *Degrees* to the Right.

In ♐ at their rising 60 *Degrees*: On the Meridian 81 *Degrees* to the Left; and at setting 73 *Degrees* to the Right-hand.

In ♑ the same as in *Cancer*.

In ♒ 82 *Degrees* on the Left: On the Meridian 86 *Degrees* to the Right; and at setting 56 *Degrees* to the Right-hand.

In ♓ at their rising near right: On the Meridian 52 *Degrees* to the right; and at setting 50 *Degrees* to the Right.

These Positions of the Luminaries in Eclipses, are more general than when laid down by the Altitude of the Nonagesime Degree, for when the Moon, &c. is in *Cancer* (as in this Eclipse before us) under the Meridian with great North Latitude, if it be laid down by the Altitude of the Nonagesime Degree it will throw her into too oblique an Position, which for your own Satisfaction you may try at your Leisure.

And for their Positions between Rising and Southing, and between their Southing and Setting, your own Reason will better direct than a Multitude of Words.

At the Time of this Eclipse, the Moon has just past the Conjunction of *Jupiter*, *Mars*, and *Saturn* you may see a little to the East all three Retrograde. *Venus* and *Mercury* are under the Earth.

8. To Construct an Eclipse of the Moon Geometrically.

The greatest Part of this Work is performed in the 7th Paragraph of this *Precept*, so that here is nothing to be done, but only to divide the Moon's Orb, into Hours and Minutes of Time; which being performed, you may presently see at any time during the Eclipse, how many Digits are darkned at that Time.

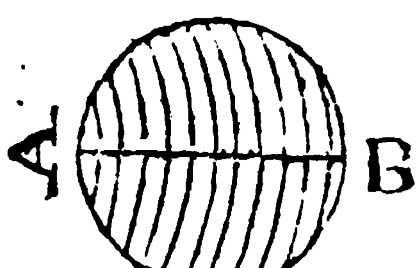
To Divide the Moon's Orb.

Consider what Hour is nearest to the middle of the Eclipse, which in this Example is Twelve at Night, whose Difference from 12 is only $11'$ $23''$; and then I say,

	Min.	*Sec.*	L L
If one Hour, or	60	00	0
Give Hourly Motion Moon from Sun	29	24	3098
What Distance from 4 o'Clock give	11	23	7219
Answer, Motion Moon from Sun	5	37	10317

Take this $5'$ $37''$ in your Compasses from the same Scale the Diagram was laid down by, and set it from the middle of the Eclipse on the Moon's Orb at P towards N, and that Point shall be the Place of the Moon at Twelve o'Clock, but had the middle of the Eclipse been after 12 o'Clock, then the Distance in the Moon's Orb must have been laid down towards M, as your own Reason will direct you better than a Multitude of Words. Take 29 Minutes 24 Seconds in your Compasses, the Hourly Motion of the Moon from the Sun, and set one Foot in the Moon's Orb at the Hour of Twelve (just now found) and turn the other Foot towards M; that shall give the Hour of Eleven at Night, and turn'd towards N, shall give the Place of the Moon at the Hour of One in the Morning: And thus you may mark out the Orb of the Moon in Hours and Minutes during the Time of the Eclipse, which you will find to agree exactly with your Calculation, distinguishing the Minutes by small Dots along the Moon's Orb.

Take the Semidiameter of the Moon $15'$ $24''$ in your Compasses from the same Scale, and upon strong Paper, or fine Card; sweep a Circle as *per* Figure, and draw the Diameter A B, which divide into 12 equal Parts, or Digits, and with the Semidiameter of the Earth's Shadow and Atmosphere 40 Minutes 30 Seconds, draw eleven Arch-lines; so shall you have the Body of the Moon divided into 12 Digits: Cut this Moon out, and put a Pin thro' the Center; carry the Point of the Pin gently along the Moon's Orb, always keeping the Point A truly to the Center



Center of the Shadow; and by this Method, you will see at every Hour and Minute of Time how many Digits and Parts of Digits of the Moon's Body are Eclipsed during the whole Time of the *Deliquium*. And by this Method Projected upon a large Sheet of Paper, I always shew Gentlemen the Nature of a Lunar Eclipse.

To Calculate a Total Eclipse of the Moon, to any particular Place on the Globe.

And for an Example I shall shew it shall be that which happen *October* 22, 1743?

Equal Time.	Long. ☉ S.	°	'	''	Anom. ☉ S.	°	'	''	Equation.		
Anno 1743,	9	20	33	18	6	12	4	42	60	0 LL	0
Octob. 21	9	19	46	49	9	19	46	1	1	5	17434
Hours 15			36	58			36	58	28	41	3205
Minutes 24				59				59	0	31	20639
Seconds 31				1				1	39	46	
Mean Mot.	7	10	58	15	4	2	28	41	39	15	
Equat. Sub.		1	39	15							
Sun's Place	7	9	18	50							

Equal Time.	Long. ☽ S.	°	'	''	Anom. ☽ S.	°	'	''	Node ☽ S.	°	'	''
Anno 1743,	4	1	14	17	7	23	54	6	1	25	3	24
Octob. 21	9	3	51	36	8	1	6	22		15	34	8
Hours 15		8	14	7		8	9	56			1	59
Minutes 24			13	11			13	4				3
Seconds 31				17				17		15	36	10
Mean Mot.	1	13	33	28	4	3	23	45	1	9	27	14
Equat. Sub.		4	14	38								
☽ in her Orb	1	9	18	50								
Node sub.	1	9	27	14								
Argu. Lat.	11	29	51	36								
Lat. ☽ S. D.		0	0	44								
Reduction				2								
Ecl. Place,	1	9	18	52								

Horiz.

	Min.	Sec.
Horiz. Motion of ☽	2	30
Horiz. Motion of ☉	35	52
Hourly Motion ☽ à ☉	33	22

Now for the Time of Reduction, say,

	Min.	Sec.		
As Hourly Motion ☽ à ☉	33	22	LL	2548
To one Hour, or	60	00		0
So Reduction	00	2		32553
To the Time	00	4		30005

	D.	H.	M.	S.
Equal Time true Orbit ☍ at *London* 1743, *Octob.*	21	15	24	31
Time of Reduction subtract and add				4
Equal Time of Ecliptic ☍	21	15	24	27
Equal Time middle	21	15	24	35
Equation Time add			16	13
Appar. Time of the Ecliptic ☍	21	15	40	40
Appar. Time of the Middle	21	15	40	48

Now Read Article 3, *Page* 419.

	Min.	Sec.
Horizontal Parallax of ☉	0	10
Horizontal Parallax of ☽	59	38
Sum	59	48
Semidiameter Sun subtract	16	14
Appar. Semi. Earth's Shadow	43	34
Semidiameter Moon add	16	12
Sum	59	46
Moon's true Lat. subtract	00	44
Remains Parts deficient	59	21

Hence, because the Moon's Latitude is less than the Difference between the Semidiameter Moon and Earth's Shadow, shews the Eclipse will be Total with Continuance.

For

For the Digits Eclipsed, say,

		Min.	*Sec.*		
As Semidiameter ☽		16	12	LL	5686
To six Digits	6	0	0		10000
So are Parts deficient		59	2		71
To the Digits Eclipsed		21	51	40	4385

4. *To find the Scruples of Incidence.*

1. *By the 47 of the first of Euclid.*

Lat. ☽ = A P 44″ Semidiameter ☽ and ⊖ Shadow =
44 = A P 59′ 46″

```
 44          59′ 46″
 ——            60
176          ————
176          3586
————         3586
1936        ——————
             21516
            28688
           17930
          10758
          —————————
          12859396
Square A P sub.       1939
          ———— ———— Seconds.
          12857460(3585.7
```

2. *By Trigonometry.*

			Seconds	
As Sum Semidiameters = A M			3586—	3.5546103
To Radius	90	0	0—	10.0000000
So ☽ Lat. = A P			44—	1.6434527
To C. s. P A M	89	17	49—	8.0888424

Again,

Again,

	Deg.	Min.	Sec.	
As Radius	90	0	0—	10.0000000
To Sum Simid. ☽ and ⊖ Shad.			3586—	3.5546103
So S. Angle P A M	89	17	49—	9.9999673
To P M Motion of Half Duration				3.5545776

Equal 3585.7 Seconds.

3. *By the Logarithms.*

OPERATION.

	Seconds.	
Sum Semid. ☽ and ⊖ Shadow	3586	
Latitude ☽ add and subtract	44	
Sum	3630—	3.5599066
Diff.	3542—	3.5492486
Sum of the Logarithms		7.1091552
Half	3585.7—	3.5545776

4. *To find the Time of half Duration, and from thence the Beginning and End of the Eclipse.*

	Min.	Sec.	
As true Hourly Motion ☽ á ☉	33	22	LL 2548
To one Hour, or	60	00	0
So are Scruples Incidence	59	45.7	17
To Time half Duration	107	28	2531

That is 1 h. 47′ 28″.

	D.	H.	M.	S.
Apparent Time Middle	21	15	40	48
Time half Durat. sub. and add		1	47	28
Appar. Time of the Begin.	21	13	53	20
Appar. Time of the End	21	17	28	16

5. To

9. To find the Scruples of half Total Darkneſs in a Total Eclipſe of the Moon, and thence the Continuance, Beginning, and End of Total Darkneſs.

RULE. From the Semidiameter of the Earth's Shadow, ſubtract the Semidiameter of the Moon; the Remainder reduce into Seconds, and alſo reduce the Moon's Latitude into Seconds; the half Sum of the Logarithms of the Sum and Difference in Seconds ſhall be the Motion of half Continuance in the Total Darkneſs, as has been ſhewn in finding the Scruple of Incidence in the Partial Eclipſe.

This half Continuance of Total Darkneſs, ſubtracted from the middle of the Eclipſe, gives the Time of the Beginning of the Total Darkneſs; and added to the Time of the middle, gives the Time of the End thereof.

	Min.	*Sec.*		*Seconds.*
Semidiameter of ⊖ Shadow	43	34	Latitude ☽	44
Semidiameter of ☽ Sub.	16	12		
	27	22		
	60			
Difference in Seconds	1642			
Latitude ☽ add and ſub.	44			

Sum	1686	Log.	3.2268576
Difference	1598	Log.	3.2035768
Sum of the Logarithms			6.4304344
Half			3.2152172

Motion of half Total Darkneſs 1641.4.
Which divided by 60 = 27′ 21″.

For the Time of half Total Darkneſs, ſay,

	Min.	*Sec.*	LL
As true Hourly Motion Moon from Sun	33	22	2548
To one Hour, or	60	00	0
So Motion of half Continuance	27	21	3412
To the Time	49	10	864

For the Beginning and End of Total Darkness.

	D.	H.	M.	S.
Apparent Time middle	21	15	40	48
Time of half Durat. Tot. Dark.			49	10
Appar. time of the Begin.	21	14	51	38
Appar. time of the End	21	16	29	58

6. *To find the Latitude of the Moon at the Beginning and End of the Eclipse.*

	Min.	Sec.	LL
As one Hour, or	60	0	0
To Sun's Hourly Motion	2	30	13802
So time of Incidence	107	28	2531
To Mot. ☉ in that time	4	29	11271
Scruples of Incidence add	59	45	
Sum	64	14	

	S.	D.	M.	S.
Argument Latitude middle	11	29	51	36
Sum, subtract and add		1	4	14
Argu. Latitude at beginning	11	28	47	22
Argu. Latitude at end	0	0	55	50

	Min.	Sec.	
Hence, the Latitude ☽ at Begin.	6	20	S. D.
Hence, the Latitude ☽ at End	4	52	N. A.

Hence, the apparent time at *London* of the

	D.	H.	M.	S.
Beginning of Eclipse 1743, *October*	21	13	53	30
Beginning Total Darkness		14	51	38
Ecliptic ☍		15	40	40
Middle		15	40	48
End of Total Darkness		16	29	58
End of the Eclipse		17	28	16
Duration Total Darkness		1	38	20
Total Duration		3	34	56
Digits Eclipsed are		21	51	40

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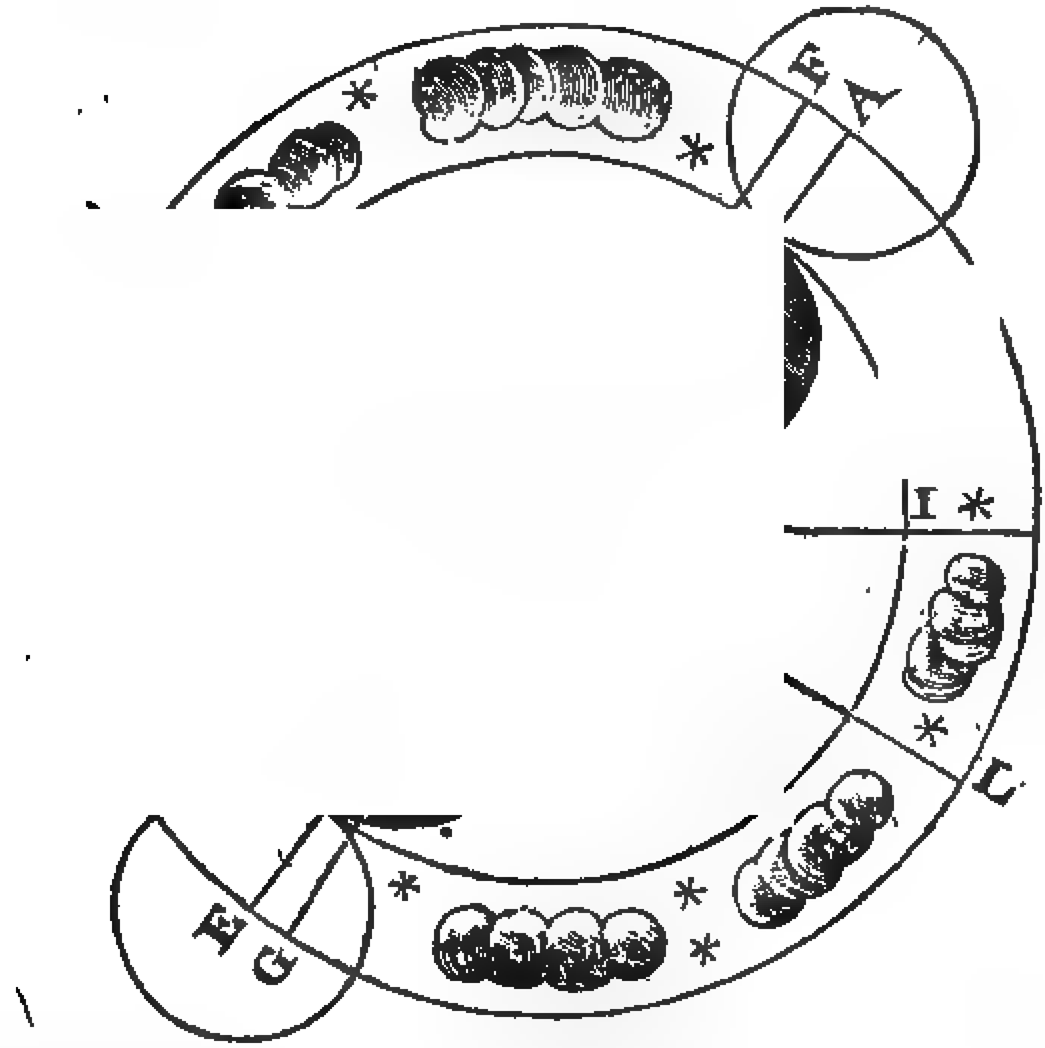


	Deg.	Min.	Sec.
Sun's Right Ascension	296	13	00
Apparent time from Noon	156	25	15
Sum R. A. *Medium Cœli*	452	38	15
Complement	92	38	15
Medium Cœli ♋	4	25	00
Meridian Angle	88	57	00
Altitude *Medium Cœli*	61	55	00
Altitude Nonagesime Degree	61	55	00

A represents the Center of the Moon at the beginning of the Eclipse; B the Moon's Center when the Total Darkness begins; C the Moon's Center at the middle of the Eclipse; D the Moon's Center at the End of Total Darkness; and E her Center at End, so that the Line A B C D E is the way of the Moon during the time of the Eclipse, and F G is the Eclipse;

HCI a Horizontal Line, HI the Diameter of the Earth's Shadow equal 87' 8''; and KL is the Axis of the Ecliptic, to which the Moon comes at the true time of the Ecliptic Opposition.

PRECEPT XVI.

To Calculate an Eclipse of the Sun, to any particular Place on the Globe.

First, By *Precept* 14, I have found that in the Year 1748, there will be four Eclipses of the Luminaries, *viz.* two of each Light: See my *Treatise of Eclipses for 26 Years*, and also my Sheet for 35 Years, ending with the Year 1761, which is Sold by my Self, and on *July* 14, there will be a great and visible Eclipse of the Sun, whose Calculation follows for the Meridian and Latitude of *London*.

PRE-

Eq. Time ☉	Long. ☉ S	°	'	''	Anom. ☉ S	°	'	''	Equation '	''		
Anno 1748	9	20	20	47	6	11	46	55	60	0	LL	0
July 13 Biss.	6	12	12	4	6	12	11	31	1	49		15189
Hours 23			56	40			56	40	56	16		279
Minutes 28			1	9			1	9	1	42	add	15468
Second 25				1				1	46	25		
Mean Mot.	4	3	30	41	0	24	56	16				
Equat. add		0	48	7					48	7		
Sun's Place	4	2	42	34								

Eq. Time ☽	Long. ☽ S	°	'	''	Anom. ☽ S	°	'	''	Node ☽ S	°	'	''
Anno 1748	2	1	20	8	10	0	34	5	10	18	21	38
July 13 Biss.	1	19	23	49	0	27	40	21		10	19	35
Hours 23		12	37	39		12	31	15			3	3
Minutes 28			15	22			15	15				4
Seconds 25				14				14		10	22	42
Mean Mot.	4	3	37	12	0	11	1	10	10	7	58	56 sub.
Equat. add		0	54	38								
☽ in her Orb	4	2	42	34								
Node sub.	10	7	58	56								
Argu. Lat.	5	24	43	38								
☽ True Lat. N.A.			27	32								
Reduct. sub.			1	12								
Ecl. Place	4	2	43	46								

	Min.	*Sec.*
Hourly Motion of ☉	2	33 23
Hourly Motion of ☽	29	37
Hourly Motion of ☽ à ☉	27	14

For the Time of Reduction.

	Min.	*Sec.*		
As Hourly Motion ☽ à ☉	27	14	LL	3431
To one Hour, or	60	00		0
So is Reduction	1	12		16990
To Time	2	39		13559

By

By the foregoing *Problems* of *the Doctrine of the Sphere*, you must carefully find the Requisites, and set them down thus:

	D.	H.	M.	S.
1. Mid. Time true ☌ in Orb 1748, *July*	13	23	28	25
Equation of time sub.			5	58
Appar. time ☌ in the ☽ Orb	13	23	22	27
Time of Reduction sub. and add			2	39
Apparent time Ecliptic ☌	13	23	19	48
Ap. time nearest Approach to Center	13	23	25	6
Sun's Place then	♌	2	42	28
Sun's Right Ascension		125	00	00
Apparent time from Noon		349	57	00
Sun R. A. *Medium Cœli*		474	57	00
Complement		65	3	0
Medium Cœli in Ecliptic	♋	23	7	0
Meridian Angle		80	19	0
Decli. Cul. Point North		21	30	0
Altitude Equation at *London* add		38	28	0
Altitude *Medium Cœli*		59	58	0
Altitude Nonagesime		60	27	0
Dist. *Medium Cœli* Nonagesime sub.		5	33	0
Nonagesime Degree	♋	17	34	0
Dist. Sun à Nonagesime East		15	8	28
Horizontal Parallax Moon and Sun			54	52
Parallax Longitude Moon from Sun			12	28
Ecliptic Place Moon add	4	2	43	46
Visible Place Moon	4	2	56	14

Read *Page* 201. And from thence you will gather, that because the Luminaries are between the Ascendant and the Nonagesime Degree, the Visible Conjunction will be before the true.

	Min.	*Sec.*
Parallax in Latitude Moon from Sun	27	4
True Latitude Moon North Descending	27	39
Visible Latitude Moon North	00	35

And because the Eclipse falls in the Oriental Quadrant, you must seek the Requisites just now found, by *Problems* 27, 28, 29, 30, 31, 32, 33, and 39; and to an Hour, (to 50, 40,

40, or to 30 Minutes, more or less, as you shall find most Convenient for the present purpose) before the Time of the true Conjunction, and set them down as you see in the following Order.

	D.	H.	M.	S.
1. To 1 Hour before the true ☌ *July*	13	22	19	48
Sun's Place	♌	2	40	5
Sun's Right Ascension		124	58	0
Apparent Time from Noon add		334	57	0
Sun's Right Ascension *Medium Cœli*		459	55	0
Complement		80	5	0
Medium Cœli in Ecliptic	♋	9	7	0
Meridian Angle		86	4	0
Declination Culminating Point North		23	10	0
Altitude Equator at *London* add		38	28	0
Altitude Mid-heaven		61	38	0
Altitude Nonagesime Degree		61	43	0
Dist. Mid-heaven à Nonagesime subt.		2	7	0
Nonagesime Degree	♋	7	0	0
Dist. of the Sun à Nonagesime East.		25	40	5
Mean Anomaly ☽	0	10	31	33
Horizontal Parallax ☽ à ☉			54	51
Parallax Longitude ☽ à ☉			20	55
Parallax Latitude ☽ à ☉			25	59

3. To find the Visible Motion of the Moon from the Sun in any Time proposed.

1. If the Eclipse happen in the Oriental Quadrant, and the Parallax of Longitude of the Moon from the Sun Increase add } Decrease subtract } the Difference of the Parallax of the Longitude the Moon from the Sun in an Hour, or in any other Time, to, or from the true Motion of the Moon from Sun, and you will have the Visible Motion of Moon from the Sun in the same Time.

2. But if the Eclipse fall in the Occidental Quadrant ([redacted] ~~the present Eclipse doth~~) and the Parallax of Longitude, Increase subtract } Decrease add } the Difference of the Parallax of Longitude Moon from Sun in an Hour, or in any other Time, to, or from the true Motion of the Moon from Sun, and you will

will gain the Visible Hourly Motion of Moon from Sun in the same Time.

	H.	M.	S.		M.	S.
At	23	19	48	Paral. Longitude ☽ à ☉ is	12	28
	22	19	48		20	55
Difference	1	00	00	Decrease sub.	8	27
True Hourly Motion Moon from the Sun					27	13
Visible Hourly Motion Moon from the Sun					18	46

Now say, for the Time of the Visible Conjunction.

	Min.	Sec.	
As Visible Hour Motion Moon from Sun	18	46	LL 5048
To one Hour, or	60	00	0
So Parallel Longitude true ☌	12	28	6824
To interval of time subt.	39	52	1766
			1776

	Min.	Sec.	
As one Hour, or	60	00	LL 0
To Sun's Hourly Motion	2	23	14010
So time from true to Visible ☌	39	52	1776
To Motion Sun in that time	1	35	15786

Because the Eclipse falls in the Oriental Quadrant, this Interval or Distance, between the True and Visible Conjunction of the Sun and Moon must be subtracted from the Time of the true Conjunction, and the Remainder is the Time of the Visible Conjunction. But when the Eclipse is in the Occidental Quadrant, you must add that Distance.

Apparent

	D.	H.	M.	S.
Apparent time true ☌ 1748, *July*	13	23	19	48
Interval ſub.			39	52
Viſible ☌ is *July*	13	22	39	56
Motion Sun in that time is			1	35
Sun's Place then	♌	2	40	53
Sun's Right Aſcenſion		124	58	0
Apparent time from Noon		339	57	15
Sum, Right Aſcen. *Medium Cæli*		464	55	15
Complement		75	4	45
Medium Cæli in Eclip.	♌	13	43	00
Meridian Angle		84	6	00
Declination Cut Point North		22	47	00
Altitude Equator at *London* add		38	28	00
Altitude Mid-heaven		61	15	00
Altitude Nonageſime		61	25	00
Diſtance Mid-heaven à Nonageſime		3	9	00
Nonageſime Degree	♋	10	34	00
Diſtance Sun from Nonageſime		22	6	53
Mean Anomaly Moon	0	10	41	26
Horizontal Parallax Moon from Sun			54	51
Parallax Longitude Moon from Sun			17	51
Diſtance of Sun and Moon			17	51
Motion Sun in 39′ 52″ is			1	35
Sum, ſubtract			19	26
Argument Latitude at true ☌	5	24	43	38
Argument Latitude at Viſible ☌	5	24	24	12
True Latitude Moon North Deſcen.			29	13
Parallax Latitude ☽ à ☉ ſub.			26	14
Viſible Latitude ☽ North Deſcending			2	59
Semidiameter Sun			15	50
Semidiameter Moon			14	56
Sum Semidiameter			30	46
Viſible Latitude Moon ſubtract			2	59
Parts Deficient			27	47

By which the middle of the Eclipſe happens after the Viſible ☌. See *Page* 61, in the Tables.

To the Parallax in Longitude Moon from the Sun at the Viſible ☌, add the Motion of the Sun in the Time between the True and Viſible ☌; that Sum ſubtract in the Oriental Quadrant; but in the Occidental add to, or ſubt. from the Argu-

ment

ment of Latitude at the Time of the true ☌; the Sum or Difference is the Argument of Latitude at the Time of the Visible Conjunction; to which find the Moon's true Latitude out of the Table, *Page* 58, and by her Parallax her Visible Latitude as you see it wrought above.

	Min.	*Sec.*	
As one Hour, or	60	00 LL	0
To the Sun's Hourly Motion	2	33	13716
So is Dist. from Visible ☌ to true	39	52	1775
To Motion Sun in that time	1	42	15491

	Min.	*Sec.*	
As one Hour, or	60	00 LL	0
To Hourly Mot. Moon from Sun	27	13	3433
To Dist. à Visible ☌ to true	39	52	1775
To Mot. Moon from Sun in that time	18	5	5208
Semediameter of { Sun	15	50	
Semediameter of { Moon	14	56	
Sum	30	46	
Visible Latitude sub.	2	59	
Remains Parts deficient	27	47	as before.

For the Digits, say,

		Min.	*Sec.*	
As Semidiameter Sun		15	50 LL	5786
To six Digits				10000
So are Parts Deficient		27	47	3344
To Digits Eclipsed	10°	31	43	7558

4. To find the Scruples of Incidence, or Motion of half Duration.

This may be done all the four Ways, as I have shewn in the Moon's Eclipse; but need not repeat them here; therefore I shall work this Example Logarithmically.

OPE-

OPERATION.

	Min.	Sec.		Min.	Sec.
Sum Semid. Sun and Moon	30	46	Lat. ☽	2	59
	60			60	
	1846			179	
	179				

Seconds { 2025 Log. 3.3064250
1667 Log. 3.2219356

Sum of the Logarithm 6.5283606
Seconds 1838 ½ = 3.2641803
Which divided by 60′ = 30′ 38″ the Scruples of Incidence.

5. To find the Visible Hourly Motion of Moon from the Sun to an Hour before the Time of the Visible Conjunction, you must repeat the Work again, as you may see here set down.

N. B. The Sun's Place is found either by subtracting Hourly Motion from his Place at Time Visible ☌, or else by reducing the apparent Time to the equal, and to that Time Calculate his true Place.

		D.	H.	M.	S.
4. One Hour before Visible ☌ *July*		13	21	39	56
Sun's Place		♌	2	38	29
Sun's Right Ascension			124	55	00
Apparent Time from Noon			324	59	00
Right Ascension *Medium Cœli*			449	54	00
Complement			89	54	00
Medium Cœli in Ecliptic		♊	29	54	00
Meridian Angle			89	58	00
Declination Culminating Point North			23	29	00
Altitude Equator at *London*			38	28	00
Altitude Mid-heaven			61	57	00
Altitude Nonagesime Degree			61	57	00
Dist. Mid-heaven à Nonagesime add			0	1	00
Nonagesime Degree		♊	29	55	00
Dist. Sun from Nonagesime East.			32	43	29
Mean Anomaly Moon		0	10	11	49
Horizontal Parallax Moon from Sun				54	51
Parallax Longitude Moon from Sun				26	10
True Hourly Motion Moon from Sun				27	13
Dist. Paral. Long. in this Hour Decr. sub.				8	19
Visible Hourly Motion Moon from Sun				18	54
Parallax Latitude Moon from Sun				25	48

	D.	H.	M.	S.
5. At one Hour after Visible ☌ *July*	13	23	39	56
Sun's Place is	♌	2	43	16
Sun's Right Ascension		125	00	00
Apparent Time from Noon		354	59	00
Right Ascension *Medium Cœli*		479	59	00
Complement		60	1	00
Medium Cœli in Ecliptic	♒	27	53	00
Meridian Angle		78	31	00
Declination Cul. Point North add		20	37	00
Altitude Equator at *London*		38	28	00
Altitude Mid-heaven		59	5	00
Altitude Nonagesime Degree		59	42	00
Dist. Mid-heaven à Nonagesime sub.		6	48	00
Nonagesime Degree	♋	21	5	00
Distance Sun from Nonagesime East.		11	38	16
Mean Anomaly Moon	0	11	10	40
Horizontal Parallax Moon from Sun			54	52
Parallax Longitude Moon from Sun			9	33
Parallax Latitude Moon from Sun			27	41
True Hourly Motion Moon from Sun			27	14
Diff. Paral. Long. in this Hour Decl. sub.			8	18
Visible Hourly Motion Moon from Sun			18	56

6. To find the Middle, Beginning, and End of the Eclipse.

By the visible Latitude of the Moon at the Time of the true and visible Conjunction; you may see the visible Latitude is N D; enter therefore the Table, *Page* 60, with the visible Latitude at the Time of the visible Conjunction 2 Minutes 59 Seconds; and take out the Motion of the Moon from the Sun, 15 Seconds; which, because the Latitude is Descending, is to be divided by the Visible Hourly Motion of the Moon from the Sun to one Hour after the visible Conjunction 18 Min. 56 Sec. and the Operation stands thus by the Logistical Logarithms.

	Min.	*Sec.*	
As Visible Hour Motion ☽ à ☉	18	56 LL	5009
To one Hour, or	60	00	0
So is Motion	0	15	23802
To the time à Visible ☌ to Mid.	0	48	18793

Visible

	D.	H.	M.	S.
Visible ☌ 1748, *July*	13	22	39	56
Add				48
Middle of the Eclipse	13	22	40	44

7. For the Time of Incidence, and the Beginning of the Eclipse.

Here you must take the Visible Hourly Motion of the Moon from the Sun to an Hour before the Visible Conjunction 21 *Min.* 17 *Seconds*, and say,

	Min.	Sec.	
As Visible Hourly Motion ☽ à ☉	18	54	LL 5017
To one Hour, or	60	00	0
So are Scruples of Incidence	30	38	2920
To the Time Incidence subtract	97	15	2097

		D.	H.	M.	S.
Middle of the Eclipse		13	22	40	44
Time of Incidence sub.			1	37	15
Beginning is	*July*	13	21	3	29

8. For the Time of Repletion, and End of the Eclipse.

Here you must take the Visible Hourly Motion of the Moon from the Sun to an Hour following the Visible Conjunction, 18 *Minutes* 56 *Seconds*, and say,

	Min.	Sec.	
As Visible Hourly Motion ☽ à ☉	18	56	LL 5009
To one Hour, or	60	0	0
So Scruples of Incidence	30	38	2920
To Time Repletion add	97	4	2089

		D.	H.	M.	S.
Middle of the Eclipse	*July*	13	22	40	44
Repletion add			1	37	4
End of the Eclipse is	*July*	13	0	17	48

10. To

9. In order to delineate a Solar Eclipse, we must have the Latitude of the Moon seen at the Time of the Beginning and End of the Eclipse, which is found at the Beginning by repeating the former Work, as is here set down.

		D.	H.	M.	S.
Beginning of the Eclipse *July*		13	21	3	29
Sun's Place		♌	2	37	29
Sun's Right Ascension			124	54	00
Apparent Time from Noon add			318	36	15
Right Ascension *Medium Cæli*			443	30	15
Complement			83	30	15
Medium Cæli in Ecliptic		♊	24	57	00
Meridian Angle			87	25	00
Declination Culminating Point North			23	21	00
Altitude Equator at *London*			38	28	00
Altitude Mid-heaven			61	49	00
Altitude Nonagesime			61	51	00
Distance Mid-heaven à Nonagesime add			1	23	00
Nonagesime Degree		♊	26	20	00
Distance Sun à Nonagesime East		1	6	17	29
Mean Anomaly Moon		0	9	51	27
Horizontal Parallax Moon from Sun				54	51
Parallax Longitude Moon from Sun				28	37
Scruples of Incidence				30	38
Sum				59	15
Distance of the Sun and Moon				59	12
Motion of the Sun in 97′ 15″ time Incidence				3	52
Sum, with Scruples Incidence, sub.				34	30
Argument Lat. at Visible ☌		5	24	24	12
Argument Latitude at Beginning		5	23	49	42
True Lat. Moon North Descending				32	13
Parallax Latitude Moon from Sun				25	52
Visible Latitude Moon North				6	21

10. For the Latitude of the Moon seen at the End of the Eclipse, you must again make a Repetition of your former Work, as in the following Order.

End

	D.	H.	M.	S.
End of the Eclipſe *July*	14	0	17	48
Sun's Place	♌	2	44	48
Sun's Right Aſcenſion		125	3	00
Apparent time from Noon		6	40	30
Sum, Right Aſcen. *Medium Cæli*		131	43	30
Complement ſhort of ♎		48	16	30
Medium Cæli in Ecliptic	♌	9	17	00
Meridian Angle		74	37	00
Declination Cul. Point North		17	58	00
Altitude Equator at *London*		38	28	00
Altitude Mid-heaven		56	26	00
Altitude Nonageſime Degree		57	47	00
Diſt. Mid-heaven à Nonageſime ſub.		9	59	00
Nonageſime Degree ♋		29	18	00
Diſt. Sun from Nonageſime Eaſt		3	26	48
Mean Anomaly Moon	0	11	36	7
Horizontal Parallax Moon from Sun			54	52
Parallax Longitude Moon from Sun			2	48
Scruples of Incidence			30	38
Difference			27	50
Diſtance of the Sun and Moon			27	50
Motion Sun in 97′ 4″ time Repletion			3	51
Scruples of Incidence add			30	38
Sum add			34	29
Argument Latitude at Viſible ☌	5	24	24	12
Argument Latitude at End	5	24	58	41
True Latitude Moon N. D.			26	14
Parallax Latitude Moon from Sun			29	15
Viſible Latitude Moon South Aſcen.			3	1

And thus from the foregoing Calculation I have found the

Appar. Time at *London* of the		D.	H.	M.	S.	
	Beginning 1748 *July*	13	21	3	29	P. M
	Viſible ☌		22	39	57	P. M
	Middle		22	40	44	P. M
	End		0	17	48	P. M
	Total Duration		3	14	19	
	Digits Eclipſed		10°	31	43	

12. To

12. To Delineate the particular Eclipse of the Sun in *Plano*.

Open the Sector to any convenient Radius, and from the Line of Lines take the Sun's Semidiameter 15 *Min.* 50 *Sec.* in your Compasses, and sweep the innermost Circle marked with the Sun's Rays, to represent the Sun; through its Center draw the Line H O to represent an Horizontal Line; with the Sum of the Semidiameters of the Sun and Moon, (which in this Example is 30 *Min.* 46 *Sec.*) describe the Circle (on the same Center) E A *t* B: Take the Altitude of the Nonagesime Degree at the Time of

the visible Conjunction 61 *Degrees* 25 *Minutes*, and set the Chord thereof from O to *t*; draw E *t* for the Ecliptic at that Time, and A B at right Angles for its Axis; Take the visible Latitude of the Moon 6 *Minutes* 21 *Seconds* North at the beginning of the Eclipse, and set it from the Center of the Sun to *e*; draw *e f* Parallel to E C, the Ecliptic: Then take the visible Latitude of the Moon at the End, 3 *Minutes* 1 *Second* South, and set it from the Sun's Center to *c*, and draw *b c* Parallel to the Ecliptic E C; draw ☾ ☽ which shall here represent the Moon's visible Way. *Lastly*, Take the Semidiameter of the Moon 14 *Minutes* 56 *Second* in your Compasses from

from the same Scale of equal Parts; and setting one Foot in ☽, describe a Circle which shall represent the Moon at the beginning of the Eclipse; with the same Extent of the Compasses set one Foot in the middle between ☾ and ☽, and describe a Circle: This represents the Moon at the time of the greatest Obscuration of the Eclipse, and will shew you likewise the Digits of the Sun then Obscured: Carry the same Extent of your Compasses, and set one Foot at ☽; draw a Circle which shall represent the Moon at the End of the Eclipse; and thus you may represent, or Typifie any Solar Eclipse to any particular Place on the Earth, in its true Position at that Time; which was first publish'd by me, in my *Treatise of Eclipses*, and which is performed by having only regard to the Altitude of the Nonagesime Degree at the Time of the middle of the Eclipse, as is shewn. Thus have I finished the practical Method of Calculating the Sun's Eclipse for a particular Place on the Globe; in which you are to observe, that whatever City or Town you would do it for, that you take the Complement of the Latitude of that Place, which is always equal to the Elevation of the Equinoctial, and apply it to the Declination of the Culminating Point, (as you may see I have done, and as I have taught in *Prob.* 31) and by duly observing the Premisses, you will truly gain the Appearance of the Sun's Eclipse at that Place, whose Complement of the Latitude you made use of in your Work.

PRECEPT XVII.

To Calculate the Times of the Principal Appearances of a Solar Eclipse under any known Meridian.

And for an Example, I shall take the Eclipse of the Sun, which will happen *July* 14, 1748?

	D.	*H.*	*M.*	*S.*
Equal time of the true ☌ is *July*	13	23	28	25
Equation of Time sub.			5	58
Apparent time in the Moon's Orb	13	23	22	27
Sun's Place from the Earth	♌	2	42	34
Moon's Place in her Orbit	♌	2	42	34
Ecliptic Place of the Moon	♌	2	43	46
Argument of Latitude	5	24	43	38
True Latitude of the Moon N. D.			27	32

	D.	H.	M.	S.
True Hour. Mot. of the Moon from the Sun			27	14
Declination of the Sun North		19	35	49
Horizontal Parallax of the Moon		0	55	2
Horizontal Parallax of the Sun sub.		0	00	10
Remains the Semidiameter of the Earth's Disk			54	52

	Min.	Sec.
Semidiameter of Sun	15	50
Semidiameter of Moon	14	56
Sum is Semidiameter *Penumbra*	30	46

Angle of the Moon's Way 5 44 00. This is taken out of the Table, *Page* 81.

	Mim.	Sec.
Semidiameter Earth's Disk	54	52
Semidiameter of the *Penumbra*	30	46
Sum	85	38
Difference	24	6

Hence, because the Semidiameter of the *Disk* and *Penumbra* is greater than the Moon's true Latitude at the equal Time of the true Conjunction, it shews the Sun (Vulgarly speaking), will be Eclipsed; or rather, that some part of the Earth's Inhabitants will be deprived of the Sun's glorious Light: And because the Moon's true Latitude is less than the Semidiameter of the Disk, it shews, the Sun will be centrally Eclipsed to some part of the Earth.

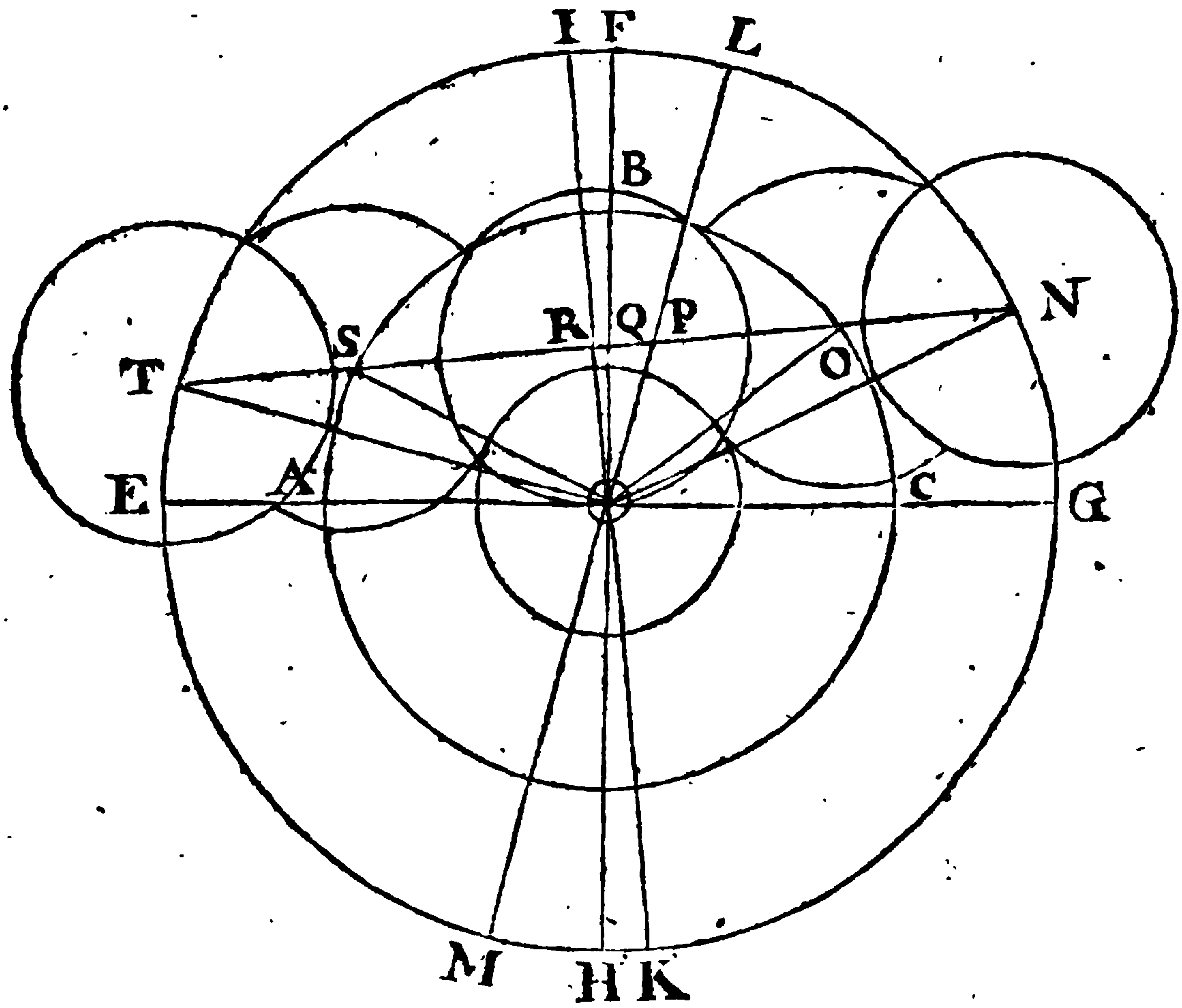
	Min.	Sec.	′	″
Semidiameter of Earth's Disk	55	10	54	52
Semidiameter of *Penumbra*	51	14	30	46
Difference	23	56	23	06

Because the Difference is less than the Moon's true Latitude, it proves, the *Penumbra* will not all fall within the Disk, and that there will be but two *Angles* of *Incidence*.

PRO-

PROJECTION.

From the Line of Lines on the Sector, take the Semidiameter of the Earth's Disk 54 *Minutes* 52 *Seconds* in your



Compasses, and set one Foot in the Center of the Sun; sweep the Circle A B C, which shall here represent the Horizon of the Disk of the Earth; from the same Scale of equal Parts take the Sum of the Semidiameters of the *Disk* and *Penumbra* 85 *Minutes* 38 *Seconds* in your Compasses, and set one Foot in the Sun as before, and draw the Circle E F G H; then draw E G to represent the Ecliptic, and F H its Axis. Now because the true Latitude of the Moon is North Descending, the Axis of the Moon's Orb will lye to the Left-hand of the Axis of the Ecliptic: Take therefore 5 *Degrees* 44 *Minutes* the Angle of the Moon's Way, from the Line of Chords, and set it from F to I, and draw I K for the Axis of the Moon's Orb. From the Scale of equal Parts take the Moon's Latitude 27 *Minutes* 32 *Seconds* North; and because 'tis North, set it on the Moon's Axis from the Sun's Center

to R, through R and at right Angles to I K, draw N T, which shall represent the Moon's Orb, or Line of her Way over the Disk, or Path of the *Penumbra*.

Take the Semidiameter of the *Penumbra* 30 *Minutes* 46 *Seconds* in your Compasses, and set one Foot in N O R S, and T severally; then draw Circles which shall represent the Center of the *Penumbra* at those Places in its Passage over the Earth's Disk: Draw Lines from the Center ⊙, to N O S and T; so shall there be several Triangles formed, *viz.* the Triangle ⊙ N R, ⊙ O R, ⊙ S R, and ⊙ T R, in which are given, first in the Triangle ⊙ N R, ⊙ N the Sum of the Semidiameters of the *Disk* and *Penumbra* 85 *Minutes* 38 *Seconds*, and ⊙ R the Latitude of the Moon 27 *Minutes* 32 *Seconds*, to find the Angle N ⊙ R the first *Angle* of *Incidence*, and N R, the Motion of the *Penumbra* from N to R, which is the half Motion of the general Eclipse.

First, *for the Angle* N ⊙ R.

	Seconds.	
As Sum Semidi. in Seconds = ⊙ N	5138	3.710794
	Min. Sec.	
To Radius	90 00	10.000000
So Moon's Lat. in Seconds = ⊙ R	1652	3.218010
To C. s. < N ⊙ R, 1st < of Incid.	71 15	9.507216

Secondly, *for the Motion of half Duration* N R, *say,*

	Min. Sec.	
As Radius	90 0 —	10.000000
To ⊙ N in Seconds	5138 —	3.710794
To S. Angle R ⊙ N	71 15 —	9.976318
To R N, the Mot. of half Dura.	4866 —	3.687112

For the Time the Penumbra *is moving from* N *to* R, *say,*

	Min. Sec.	
As true Hourly Motion ⊙ à ☽	27 14	LL 3431
To one Hour	60 00	0
So Mot. of half Duration = N R	81 06	1309
Sum 1st and 3d Logarithms		4740

Hence,

Hence, becauſe the Proportion above will exceed the Tables of Logiſtical Logarithms, you muſt take half the Numbers, and what comes out muſt be doubled, and that will be the true Anſwer.

OPERATION.

	Min.	*Sec.*	
As true hourly Mot. ☽ à ☉ from	27	14	LL 3431
To half Hour, or ſub.	30	00	3010
So Motion = N R and	81	06	1309
Sum 1ſt and 3d Logarithms			4740
To half the Time	89	21	1730
Doubled is the Time	178	24	
Equal 2 H. 58 Min. 42 Sec.			

Secondly, In the Triangle ☉ R O, there are given ☉ O, the Semidiameter of the Disk 54 *Minutes* 52 *Seconds*, and ☉ R the Moon's Latitude, to find the Angle R ☉ O, the ſecond Angle of Incidence, and R O the half Motion of the Central Eclipſe.

Firſt, *For the Angle* R ☉ O.

	Seconds.	
As Semid. ⊖ Disk in Seconds ☉ O	3292—	3.517460
To Radius	90 00—	10.000000
So Moon's Latitude = ☉ R	1652—	3.218010
To C. ſ. < R ☉ O	59 53—	9.700550

Secondly, *For the Motion* R O, *ſay*,

	Deg. Min.	
As Radius	90 00—	10.000000
To ☉ O	3292—	3.517460
So S. < R ☉ O	59 53—	9.937019
To R O	2848—	3.454479

Laſtly,

Lastly, *For the Time, say,*

	Min.	Sec.	
As true hourly Mot. ☽ à ☉	27	14	LL 3431
To one Hour, or	60	00	0
So is the Motion O R 2848'' =	47	28	1018
To the Time	104	35	2413

3. We are to find the Inclination of the Axis of the Globe with the Axis of the Ecliptic.

ANALOGY.

	Min.	Sec.
As Radius	90	00—10.000000
To C. f. of the Sun's Longitude	57	17— 9.732784
So t. of the greatest Reflection	23	29— 9.637956
To t. of the Inclination	13	13— 9.370740

Now you are to observe, that if the Sun be in { ♋ ♌ ♍ ♎ ♏ ♐ / ♑ ♒ ♓ ♈ ♉ ♊ } the Axis of the Globe lies to the { Right-Hand / Left-Hand } of the Axis of the Ecliptic.

Open the Sector to the Radius ☉ F on the Line of Chords, and take of the Chord of the Inclination 13 *Degrees* 13 *Min.* and set it from F to L; draw L *R*, and that shall be the Axis of the Globe projected in the Earth's Disk.

Now because the Axis of the Globe, and the Axis of the Moon's Orb lie both on contrary Sides of the Axis of the Ecliptic, therefore the Angle ☉ R P is Affirmitive; then to the Angle ☉ Q P 13° 13'' add the Angle ☉ R Q 5° 44', the Sum is the Angle ☉ R P 18° 57' the Angle of Direction. Now to find the Motion R P.

4. In the Triangle R ☉ P, right Angled at R, are given the Angle of Direction R ☉ P = 18° 57' (that is the Inclination of the Axis of the Globe + the Angle of the Moon's Way) and ☉ R the Moon's Latitude = 27' 32'', to find R P.

ANA-

ANALOGY.

	Min. Sec.	
As Radius	90 00—	10.000000
To ☉ R, ☽ Latitude in Seconds	1650—	3.218010
So t. Angle R ☉ P	18 57—	9.535739
To R P the Motion	567.2—	2.753749

This 567 *Seconds is equal to* 9 *Minutes* 27 *Seconds to Reduce it to Time, say,*

	Min.	Sec.	L.L.
As true Hourly Mot. ☽ à ☉	27	14	3431
To one Hour, or	60	00	
So is the Motion R P	9	27	8027
To the Time	20	49	4596

These 20 *Minutes* 49 *Seconds* added to the apparent Time of the Middle, give the apparent Time when the Meridional Sun will be Centrally Eclipsed.

And by the foregoing Calculation of this general Eclipse I have found,

	D.	M.	S.
The first Angle of Incidence	71	15	00
The Second	59	53	00
The Mot. of half Duration of this general Eclipse	81	6	00
The Motion of Semiduration of this general Eclipse in the Disk	47	28	00
From the Axis of the Globe to the Axis of Moon's Way	9	27	00
Hence, half the Time of the general Eclipse	2	58	42
Half Duration of the Central Eclipse	1	44	35
Time from the Axis to the Middle sub.	0	20	49

5. For

5. *For the nearest Approach of the Moon to the Center of the Disk.*

		D.	H.	M.	S.
Apparent time true ☌ in the ☽ Orb	*July*	13	23	22	[illegible]
Time of Reduction subtract and add				2	[illegible]
Ecliptic ☌		13	23	19	45
Middle		13	23	25	6

Having found the middle of the Eclipse, or the apparent Time when the Center of the *Penumbra* comes to R, if to and from that you subtract and add the Semidurations severally, you will have the Beginning and End of the general Eclipse.

EXAMPLE.

		D.	H.	M.	S.
Middle of the Eclipse	*July*	13	23	25	6
Semiduration subtract and add			2	58	42
Beginning of the Eclipse		13	20	26	24
End		14	2	23	48
Half Durat. of the Cen. Eclip. sub. and add			1	44	35
Beginning of the Central Eclipse		13	21	40	31
End		14	1	5	41

From the foregoing Calculation I have found at *London* the Times when

The *Penumbra* first touches the Disk, and the Eclipse first of all begins, its Center is then at N, 13 *Days* 20 *Hours* 26 *Minutes* 24 *Seconds.*

The

	D.	H.	M.	S.
he Center of the *Penumbra* enters the Earth's Disk at O, and the Central Eclipse first begins	13	21	40	31
'he Meridional Sun is Cen. Eclipsed at P	13	23	4	47
'he Nonagesime Sun is Cen. Eclipsed at Q	13	23	19	48
Iiddle of the Eclipse, or the Center of the *Penumbra* is now at R	13	23	25	6
Center of the *Penumbra* passes off the Earth's Disk, and the Central ends at S	14	1	5	41
The *Penumbra* passes off the Disk, and the Eclipse ends in all Places, the Center is at T	14	2	23	48
After they have continued in passing over the Earth	14	5	57	24

Lastly, To determine the Latitude of those Places on the Globe, and their Longitude from *London*, where any of those Appearances happen: But having largely treated on this Subject in my *Uranoscopia*, to which I refer my Reader, I shall here only set down the Places themselves which take as follows.

Hence, the Latitude and Longitude from *London* where

	Lat. °	′	*Long.* °	′
Sun begin. Ecl. at Rising	35	9 N	51	10 W
Rises Centrally Eclipsed	45	23	76	17 W
Central Eclipse in the Meridian	51	38	14	13 E
Central Eclipsed in the Nonagesime	48	47	20	8 E
Sets Centrally Eclipsed	10	30	76	22 E
End at Sun Setting	0	14 S	53	59 E
Sun's lower touched by ☽ upper Limb in the Meridian beyond the Pole.				
Sun's upper touched by ☽ lower Limb	21	19 N	14	13 E

PRECEPT XVIII.

To Construct the Sun's Eclipse Geometrically.

The Projection that I shall here describe, is that mentioned by Mr *Flamsteed* in the 27th Page of his *Doctrine of the Sphere*; that is, if a Plane be conceived to touch the Moon's Orbit in that Point, wherein a Line connecting the Centers of the Earth and Sun, intersects the said Orbit, and stands at right Angles to the aforesaid Line; and if an infinite Number of strait Lines be supposed to pass from the Center of the Sun, thro' this Plane of the Periphery of the Earth, to its Axis, as likewise to the Axis of the Ecliptic, and the Path of any Vertex; the said Lines will Othographically project the Earth's Disk, its Axis, the Axis of the Ecliptic, and the Path of the Vertex, on the aforesaid Plane. And this is the Projection we are to delineate.

In *Problem* 3, of *the Projection of the Sphere*, I have shewn how the Path of any Vertex may be drawn; and that when the Sun's apparent Place is either in *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo* or *Virgo*, the North Pole of the Globe lies in the illuminated Part of the Disk: But if the Sun be in *Libra*, *Scorpio*, *Saggitary*, *Capricorn*, *Aquarius*, or *Pisces*, then the North Pole lies in the Obscure Hemisphere.

If the Sun be in the Equinoctial, the Paths of the Vertices, will be projected in right Lines upon the said Plane; but if the Sun be not in the Equinoctial, then the Path will be Ellipses upon the said Plane.

The Transverse Diameter of the Ellipsis representing any Path is equal to double the right Line of the Distance of the said Vertex from the Pole; that is, equal to twice the Co-Sine of the Latitude of the Place or Vertex; but the Conjugate, to the Difference of the right Sines of the Sum and Difference of the Distances of the Path and Sun from the Pole; that is, equal to the Sine-Complement of the Sun's Declination added to the Co-Latitude of the Place, less the right Sine of the Difference of the Complement of the Sun's Declination and the Co-Latitude of the Place.

The Transverse Diameter lies at right Angles to the Earth's Axis, and the Conjugate coincides with it. For an Example I shall

ſhall conſtruſt the Eclipſe of the Sun which will happen *July* 14, 1748, for *London*.

Open the Sector to any convenient Diſtance, as ☉ A, and draw the Semicircle A B C; this ſhall repreſent the Southern half of the Earth's illuminated Disk projected on the Plane of the Ecliptic A ☉ C.

Take the Chord of 23 *Degrees* 29 *Minutes*, the conſtant Diſtance of the Pole of the Ecliptic and the Pole of the Equinoctial, and ſet it from B, to *d* and *e*; draw *d e*, in which the Pole of the Globe will be always found.

Make *d* G = *g e* the Radius of a Line of Sines, and ſet off the Sine of the Sun's Diſtance from the Solſtial Colure ♑ 32° 42′ 34″; (becauſe the Sun at the Time of the true ☌ is in ♌ 2° 42′ 34″) and if the Sun be in ♋, ♌, ♍, ♎, ♏, or ♐, then the Axis of the Globe muſt lie to the Right-hand of the Axis of the Ecliptic; but if the Sun be in ♑, ♒, ♓, ♈, ♉, or ♊, then to the Left. So in our Example, the Sun being in ♌, I ſet the Sine of 32° 43′ from G to P, and draw P ☉ for the Axis of the Globe. Or by Calculation it will always hold as in *Page* 454.

	Deg.	*Min.*	
As Radius	90	00—	10.000000
To C. ſ. Sun's Longitude	57	17—	9.732784
To t. Diſtance of the two Poles	23	29—	9.637956
To t. Inclination two Axis = ∠ P ☉ B.	13	13—	9.370740

Take the Chord of 13° 12′ (the Sector being ſet to the Radius ☉ B) in your Compaſſes, and ſet one Foot in B, the other Foot will reach almoſt to *d*; draw *d* P ☉, and it will repreſent the Axis of the Globe, as was found juſt before by Projection.

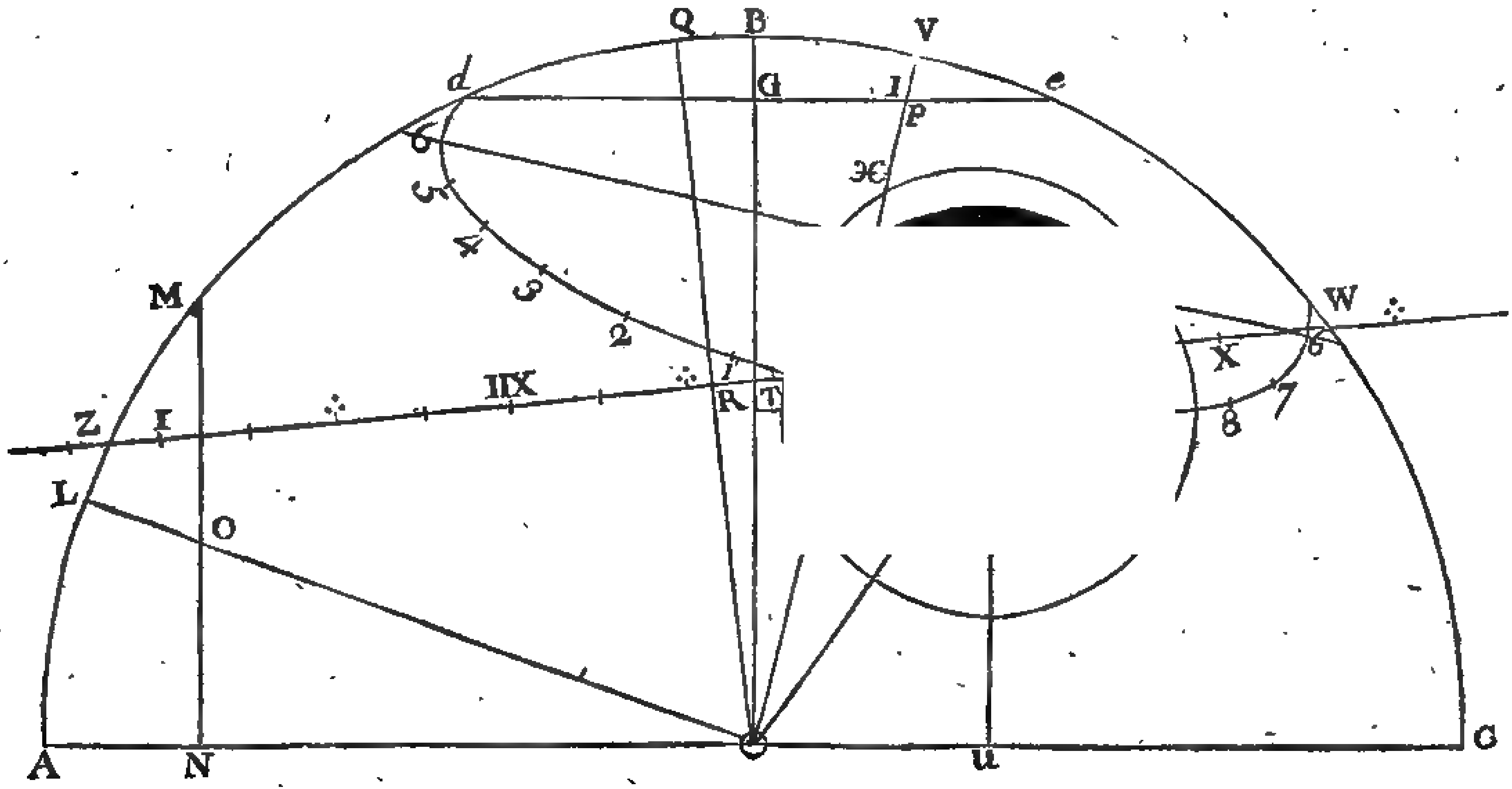
The next thing to be done, is to draw the Path of the Vertex of *London*; for the doing of which you muſt always have in readineſs the Sun's Declination, which in this Example is 19° 35′ 49″ North; which being known, added to, and ſubtracted from the Latitude of the given Place, gives the Sun's Diſtance from the Vertex of the given Place at Noon and at Midnight in North Latitudes, if the Sun have South Declination; but if the Sun have North Declination, the Sum is the Diſtance at Midnight, and the Difference the Diſtance at Noon.

	Deg.	Min.	Sec.	
Latitude	51	32	0	North.
Sun's Declination ſub. add, &c.	19	35	49	
Sum	71	7	49	Midnight.
Difference	31	56	11	Noon

See my *Uranoſcopia* Page 587, is a Table for this purpoſe to every Degree of Declination for the Latitude of *London* 51° 32′ North.

Make ⊙ B the Radius of a Line of Sines on the Sector, and take the Sine of 71° 7′ 49″ in your Compaſſes, and ſet it from ⊙ to I; alſo take 31 *Degrees* 56 *Minutes* 11 *Seconds* and ſet it from ⊙ to H; ſo is H the Meridional Interſection of the Diurnal Arch of the Path with the Axis, and I the Interſection of the Nocturnal Arch of the Path of the Vertex of *London* with the Meridian.

Biſſect



Q
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Bissect H I in K, through K, at right Angles to P ⊙; draw an occult Line; then from the same Radius of the Line of Sines take the Sine of 38 *Degrees* 28 *Minutes*, the Complement of the given Latitude, and set one Foot of your Compasses in K; turn the other each way to 6, 6; draw the Line 6, 6, and it shall represent the Transverse Diameter of the Earth's Ellipsis to the Vertex of *London*, and H I the Conjugate.

Make half the Transverse, *viz.* 6 K the Radius of a Line of Sines, and take the Sines of 15, 30, 45, 60, 75° severally in your Compasses, and set them severally in the Transverse Diameter from K each way towards 6, 6; thro' these Points, draw Occult Lines parallel to P ⊙; make H K the Radius of a Circle on the Line of Sines, and take the Sines of 75, 60, 45, 30, 15°, and set one Foot in the transverse Diameter severally on each side K, at 15, 30°, &c. and let the other Foot fall in the occult Line; so will you have Points through which with an even Hand if you draw a Curve, it will be an Ellipsis, and represent the Path of the Vertex of *London*, to which set the Figures 12, 1, 2, 3, &c. as in the Diagram: *Note*, You need only draw the Diurnal Path. And this no more than laying down an Ellipsis by the Line of Sines, which I presume every one of my Readers are well skill'd in doing. See my *Mathmatics* page 152.

Take the Sun's Declination 19 *Degrees* 36 *Minutes* from the Line of Chords in your Compasses, and set it from A to L; draw ⊙ L, take the Co. Latitude of *London* 38 *Degrees* 28 *Minutes*, and set it from A to M, let fall M N, Perpendicular to the Ecliptic A C, and it will cut L ⊙ in O; transfer ⊙ O in the Axis from ⊙, and it will reach (in this Example) almost to K; through this Point if you draw a Line parallel to 6, 6, it will give you the Amplitude of the Path of the Vertex of *London*, and does shew you that the Sun that Day rises before Six in the Morning, and sets after Six at Night. Otherways, by Calculation thus,

	Deg.	*Min.*	
As C. s. Sun's Declination *c*	19	36	9.9740774
To Radius	90	0	10.0000000
So S. of the Latitude of *London*	51	32	9.8937452
To C. s. of the Arch *d* S	33	47	9.9196678

As by the Projection above described.

How

How to place the Moon's Orb in the Projection.

With the Argument of Latitude 5 S. 24 *Degrees* 43 *Minutes* 38 *Seconds* at Time of the true Conjunction, and true hourly Motion of the Moon from the Sun 27 *Minutes* 14 *Seconds*, take out of the Table, *Page* 81, the Angle of the Moon's visible Way 5 *Degrees* 44 *Minutes*, and because the Moon's Latitude is N. D. set it by help of the Line of Chords from B to Q, and draw ☉ Q for the Axis of the Moon's Orb. Set the Line of Lines on the Sector to the Radius of the Earth's Disk B ☉ = 54 *Minutes* 52 *Seconds*, and, as the Sector now stands, take off the Moon's true Latitude 27 *Minutes* 32 *Sec.* at the Time of the true Conjunction, and set in the Axis of the Moon's Orb from ☉ to R; through R, at right Angles to Q ☉ draw W Z, which shall represent the Way of the Moon over the Earth's Disk during the time of the Eclipse.

To divide the Moon's Orb.

	D.	H.	M.	S.
The middle Time of the true Conjunct. is *July*	13	23	28	25
Equation of Time sub.			5	58
Apparent Time of the Orbit-Conjunction	13	23	22	27
Time of Reduction add			2	39
Apparent Time middle of the Eclipse	13	23	25	6

That is, when the Moon's Center passes the Axis of her Orb, being 25 *Minutes* 6 *Seconds* past Eleven o'Clock.

Now say,

	Min.	*Sec.*	
As one Hour, or	60	0 LL	0
To true Hourly Motion Moon from Sun	27	14	3431
So Time more than Eleven o'Clock	25	06	4086
To Motion Moon from the Sun in that time	11	23	7517

Take

Take this 11 *Minutes* 23 *Seconds* in your Compasses from the Line of Lines on the Sector open'd to the Radius of the Disk 54 *Minutts* 52 *Seconds*, and set one Foot in the Intersection of the Moon's Orb with its Axis; turn the other Foot towards the Right-hand, and where it falls is the Hour of Eleven: Then take 27 *Minutes* 14 *Seconds* in your Compasses from the same Scale of equal Parts, set one Foot in the Moon's Orb at Eleven, and turn the other Foot each way, and it will mark out the Hours of 12 and 10 o'Clock, or the Places in the Orb where the Center of the *Penumbra* will be at those Hours.

Lastly, Divide each Hour into 60 equal Parts, and then you will have given the Place of the Moon's Center in the Line of her Way to every single Minute in Time.

To find the Time of the Visible Conjunction.

Having divided the Path of the *Vertex*, and the Line of the Moon's Way into their proper Hours, *&c.* take a Ruler and lay on the Moon's Way, and move it at right Angles therewith from the Right-hand to the Left, until the Edge thereof cut the same Hour and Minute in the Line of the Moon's Way, that it doth in the Path of the *Vertex*; for that is the true Time of the Visible Conjunction at that Place for which the Path was drawn. So in this Example I find the Visible Conjunction at *London* to be at 39 *Minutes* 56 *Seconds* past Ten in the Forenoon.

From the same Scale of Minutes take the Semidiameter of the Sun 15 *Minutes* 50 *Seconds* in your Compasses and set one Foot in the Path of the *Vertex* of *London* at the Hour and Minute of the Time of the Visible Conjunction, and there describe a Circle which shall represent the Body of the Sun, at that Time and Place.

Also, from the same Scale take the Semidiameter of the Moon 14 *Minutes* 56 *Second* in your Compasses, and set one Foot in the Line of the Moon's Way at the time of the Visible Conjunction, and there describe a Circle; this shall represent the Body of the Moon at that Time and Place.

Divide the Sun's Diameter into 12 equal Parts, by setting the Sector to the Radius of 12 upon the Line of Lines; from which take the Sun's darkned Space, and apply that Extent of the Compasses to the Sector open'd as now directed, and you will have the Digits of the Sun's Diameter then Eclipsed; which in the Eclipse before us is 10 *Degrees* 31′ 43″.

To

To find the Beginning of the Eclipse.

Take the Sum of the Semidiameters 30 *Minutes* 46 *Seconds* in your Compasses from the Line of Lines on the Sector open'd to the Radius of the Earth's Disk 54 *Minutes* 52 *Seconds*; and carry this Extent of the Compasses one Foot along the Moon's Way, and the other along the Path of the *Vertex* until both Points fall in the same Hour and Minute, and that is the beginning of the Eclipse: Which in this Example you will find to be *July* 13 *Days* 21 *Hours* 3 *Minutes* 29 *Seconds.*

For the End.

Carry the former Extent of your Compasses on towards the Left-hand, one Foot in the Path of the *Vertex*, and the other in the Moon's Way, till each Point fall in the same Hour and Minute of Time, and that is the apparent Time of the End of the Eclipse: Which in this Example you will find to be *July* 14 *Days* 0 *Hours* 17 *Minutes* 48 *Seconds*, the End of this Solar Eclipse at *London.*

In which Construction,

				Min.	*Sec.*
T S	the Parallax of	Long.	Moon à Sun which	18	9
S U		Latit.	measur. on the Scale	26	16
☉ S		Altit.	of equal Parts is		

And as this Method is entirely free from all Parallaxes; so by it you may readily Construct any Solar Eclipse for any Latitude, or Occultation of the fixed Stars or Planets, as has been taught in this Solar Eclipse; only minding to project them by a Sector of a Foot Radius, and let the Projection be as large as possible.

PRECEPT XIX.

To Calculate the Transit of Venus *and* Mercury *over the Sun.*

For an Example I shall here shew how to Investigate the Passage of *Venus* over the Sun *May* 26, *Anno* 1761.

First, You must find the Time of the true Conjunction by *Precept* 7, having regard to the Motion of *Venus* from the Sun instead of the Table, in *Page* 65. Vol. 2.

	D.	H.	M.	S.
Equal Time of the true ☌ at *London* 1761 *May*	25	17	55	00
Equation of Time add			1	51
Apparent Time in *Venus*'s Orb	25	17	56	51
Mean Anomaly of Sun	11	6	2	24
Mean Anomaly of *Venus*	19	7	29	30
Heliocentric Place of *Venus*	8	15	36	39
Geocentric Place of Sun and *Venus* R	2	15	36	39
Anomaly of Commutation	6	0	0	0
Hourly Motion of Sun			2	23
Hourly Motion of *Venus*			1	39
Hourly Motion of *Venus* à Sun			0	44

True Distance of Sun from the Earth	101547	5.006683
True Distance of *Venus* from the Sun	72642	4.861192
Remains Distance *Venus* from the Earth	28905	4.460973

	D.	H.	M.	S.
North Node of *Venus*	2	14	29	36
Argument Latitude	6	1	7	3
Reduction sub.				7
Inclination, or Heliocentric Lat. S. A.			3	58

With the mean Anomaly take out of their Tables, the Logarithms of their Distance from the Sun and Earth, and to those Logarithms (by *Problem* 58) find the absolute Numbers to them; then subtract the absolute Number of *Venus*, from that of the Sun, and the Remainder will be the absolute Number of *Venus* from the Earth in Parts; to which Parts, find by *Problem* 57, the Logarithm thereunto, as you see are inserted above.

Now for the Latitude of *Venus* seen from the Earth at the Time of his true Conjunction with the Sun, say as is taught in my *System of the Planets Demonstrated*, Page 24.

OPERATION.

As the Dist. of *Venus* from the Earth	28905 Co. Ar.	5.539027
To Tangent Inclination	2' 58''	7.061622
So Distance *Venus* from Sun	72642	4.861192
To Tangent Geocentric Latitude S. A.	9 57	7.461841

Now you must find the Geocentric Places of the Sun and *Venus* to six Hours before the Time of the true Conjunction.

To

	D.	H.	M.	S.
To six Hours before the true ☌ *May*	25	11	55	00
True Geocentric Place of Sun	2	15	22	19
True Geocentric Place of *Venus*	2	15	47	23
Mean Anomaly of Sun	11	5	47	37
Mean Anomaly of *Venus*	10	7	5	28
Heliocentric Latitude			2	33
Geocentric Latitude			6	17
Geocentric Latitude at true ☌			9	57
Difference in Latitude			3	40
Elongation			23	56

Again:

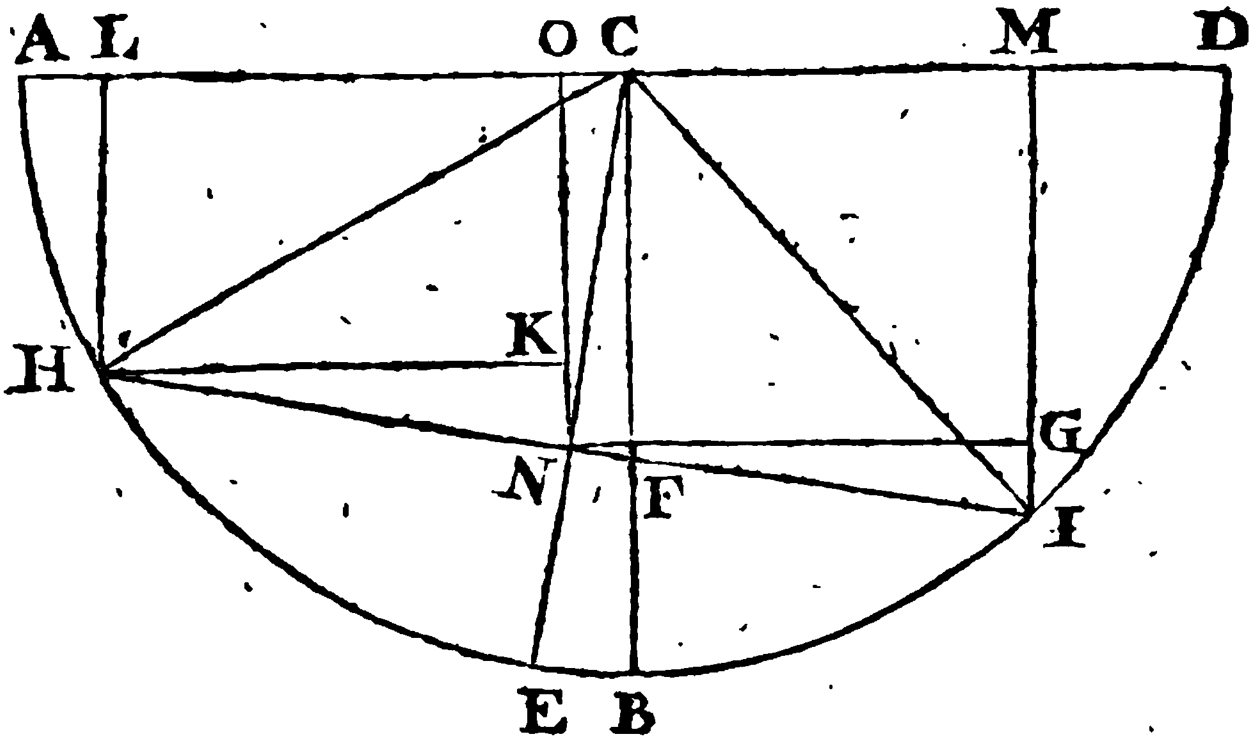
To Six Hours after the true Conjunction.

	D.	H.	M.	S.
True Geocen. Place of Sun	2	15	50	58
True Geocen. Place of *Venus*	2	15	27	41
Mean Anomaly of Sun	11	6	17	11
Mean Anomaly of *Venus*	10	7	53	32
Latitude of *Venus* S. A.			13	23
Elongation			23	18
Elongation 6 Hours before ☌			23	56
Sum			47	14
Half			23	37
			60	
Seconds			1417	

Now for the Angle of Venus's *Visible Way over the Sun, say,*

	Seconds.	
As half Sum Elongation	1417	3.1513699
	Deg. Min.	
To Radius	90 00	10.0000000
So half Difference Latitude	213	2.3283796
To t. < Visible Way	8 33	9.1770097

Open the Sector to any convenient Radius, and take the Semidiameter of the Sun 15 *Minutes* 50 *Seconds* (found in the Table, *Page* 62) in your Compasses, and draw the Semi-circle



A B D, which ſhall repreſent half the Sun's lower Viſible Periphery, A D, a Portion of the Ecliptic: Open the Compaſſes to Chord of 60 *Degrees* on the Sector to the Radius C B, and take the Chord of 8 *Degrees* 33 *Minutes* the Angle of *Venus*'s Viſible Way; and becauſe *Venus* is Retrograde, and Latitude aſcending, ſet the Chord 8 *Degrees* 33 *Minutes* from B to E, and draw C E for the Axis of *Venus*'s Viſible Way; take the Latitude 9 *Minutes* 57 *Seconds* at the Time of the true Conjunction, and ſet it on the Axis of the Ecliptic from C to F; draw H I through the Point F at right Angles to C E; ſo ſhall H I be the Viſible Way of *Venus* over the Sun: Draw H L, N O, and I M Parallel to B C the Axis of the Ecliptic, and H K, and N G Parallel to the Ecliptic A D. Then is C F the Latitude at the Time of the true Conjunction, C N the neareſt Diſtance of the Centers of the Sun and *Venus*. N O the Latitude of *Venus* at the middle of the Eclipſe, H L the Latitude at the Beginning, I M her Latitude at the Central Egreſs or End: For becauſe *Venus* is always Retrograde at the Time ſhe is ſeen in the Sun, therefore ſhe touches the Sun's Disk at H, and goes off at I.

From this Demonſtration it is plain, that H K = N G, H N to N I, and N K to G I.

Likewiſe the Angles K H N, G N I, C N O, and B C E or F C N are equal to the Angle of the Viſible Way of *Venus* with the Ecliptic, which was found above to be 8 *Degrees* 33 *Minutes*.

N F, is the Motion of *Venus* from the Sun in Longitude in the interval between the true Conjunction and the middle of this Eclipſe, H K = L O = N G = O M the Motion of half Duration. And laſtly, A H and D I are the Arches of the Sun's Viſible

Visible Periphery intercepted between *Venus* and the Ecliptic in her Ingress and Egress.

Now having explain'd the Nature of the Calculation, I shall proceed to find the Requisites by plain Trigonometry in the following Order.

First, In the Triangle CNF, right Angled at N, are given CF the Latitude of *Venus* 9 *Minutes* 57 *Seconds* at the true Conjunction, and the Angle FCN 8 *Degrees* 33 *Minutes*, to find CN, the nearest Approach of their Centers, which I find to be 9 *Minutes* 50 *Seconds*.

Secondly, In the Triangle NOC, right Angled at O, are known CN $590''.4$, and the Angles as before, to find OC the Motion from the middle of the true Conjunction, which I find to be 87.77 *Minutes*.

Thirdly, In the same right Angled plain Triangle NOC, with the same Things given to find NO, the Latitude of *Venus* at the middle, which I find to be 583.8 *Seconds* = 9 *Min.* 44 *Seconds*.

Fourthly, In the Triangle CHN = $\triangle$ CIN, there are given CN 590.4 *Seconds*, the nearest Approach of *Venus* to the Center of the Sun, and CH = CI the Sun's Semidiameter in Seconds 950 *Seconds*, to find HN = NI the Motion of half Duration, which by the 47th of the first of *Euclid*, I find to be 745.1 *Seconds* = 12 *Minutes* 25 *Seconds*.

Fifthly, In the Triangle HNK, are given HN = NI 745.1 *Seconds*, and the Angle HNK 8 *Degrees* 33 *Minutes* 745.1 *Seconds*, to find HK = NG, which I find 753.5 = 12 *Degrees* 33 *Minutes*. 25

Sixthly, In the same Triangle, there are given as before, to find NK = IG, which I find to be 112 *Seconds*, and ON 583.8 — KN 112 = OK 571.8 *Minutes* = LH the Latitude of *Venus* when she first touches the Sun's Periphery. Also ON 583.8 *Seconds* + GI 112 *Seconds* = MI 695.8 *Seconds* the Latitude of *Venus* when she goes off the Sun's Disk.

Seventhly, Having found the Motions of all the Arches of *Venus's* Passage over the Sun, I shall shew how to find the Times that she takes to move over those Spaces of her Orb, thus.

First,

First, *For the Time that She moves from* O *to* C, *say,*

		Min.	*Sec.*	
As the $\frac{1}{6}$ part of the Elong.	236.1	3	56	LL 11834
To one Hour, or		60	00	0
So is the Motion O C .	87.77	1	28	16118
To the Time sub.		22	22	4284

8. *For the Time of half Duration.*

		Min.	*Sec.*		*Min.*	*Sec.*	
As $\frac{1}{6}$ part of Elongation		3	$56\frac{1}{2}$	=	1	58	LL 14844
To one Hour, or		60	$00\frac{1}{2}$	=	30	00	3010
So is the Motion H K		12	$25\frac{1}{2}$	=	6	$12\frac{1}{2}$	9852
To the Time of $\frac{1}{2}$ Durat.	3	9	24		189	42	1982
					Sum		12862

9. *For the Arch* AH, *in the* △ CHL.

	Sec.	
As Semidiameter ⊙, CH =	950	2.9777236
	Deg. Min.	
To Radius	90 00	10.0000000
So C H Latitude at beginning	471.8	2.6737579
To S. A H = < H C L	29 46	9.6960343

Lastly, For the Arch D I. In the Triangle C I M, there are given C L, the Sun's Semidiameter, and the Latitude of *Venus* when she goes off the Disk = M I, to find the Angle M C I, which is measured by the Arch D I.

	Sec.	
As C I =	950	2.9777236
	Deg. Min.	
To Radius	90 00	10.0000000
So M I =	695.8	2.8424844
To S. Angle M C I = Arch D I	47 5	9.8647608

Now

Now, from the foregoing Calculation I have found.

	D.	H.	M.	S.
Ap. Time true Conjunction 1761 *May*	25	17	56	51
Time from O to C, sub.			22	22
Middle of the Eclipse at N	25	17	34	29
Half Duration sub. and add		3	9	24
Central Ingress, or Beginning	25	14	25	5
Central Egress, or End	25	20	43	53
Total Duration		6	18	48

		Min.	*Sec.*	
Lat. ♀ at	Beginning	7	51	S. A.
	Middle	9	50	
	Ecliptic 6	9	57	
	End	11	35	

The TYPE.

At the middle Time of this Transit of *Venus*, she may be seen in the Sun not much unlike a Patch on a Lady's Face, and the Sun is then Vertical to the North, in Latitude 22 *Degrees* 42 *Minutes* North, and Longitude 91 *Degrees* 15 *Minutes*, East from the Meridian of *London*; consequently Visible to all *Europe*, *Africa*, and part of *Asia*.

Venus is seen in the Sun by the Inhabitants of our Earth but twice in this Century, and that of *Mercury* sixteen Times; whose Calculation all at large I have now by me in *M. S.* [See my *Treatise of Eclipses.*] If the Type of *Venus* and *Mercury* be projected by a large Scale, and their Orb, or Visible Way be divided into Hours and Minutes of Time, as has been shewn in dividing the Moon's Orb in *Page* 463, it will pleasantly represent to your View at every Moment of Time the Place of the

the Planet during the Time of its Transiting the Sun's Disk. So that he, who is able, and fitted with proper Instruments to observe the Times, I do not at all doubt, but will find them to agree with my Calculations.

PRECEPT XX.

Shewing how to compute the true Times of the Immersion and Emersion of the first Satellite of Jupiter.

These Tables of this Satellite were first published in the *Philosophical Transactions* by *M. Cassini*, and reduced to the following Method by Mr *Pound* in the said *Transactions*: 'But 'because the Eclipse of the first Satellite of *Jupiter* affords 'the best Mean of determining the Longitude of Places on 'the Land where Telescopes of a convenient length may be 'used, thirteen of these Eclipses happening every twenty 'three Days, it is requisite that the Observer know near 'when these Opportunites offer themselves, lest on the one 'Hand he let them slip, or else grow weary by a long Atten- 'dance on them, *Phil. Trans.* N° 361.

Out of the first Table take the Epoche for the Year with its corresponding Number A and B; and then add, out of the Tables of Months, the Day, Hour, Minutes and Seconds, nearest less than the Time of the Eclipse you seek, together with its Number A and B; the Sum of the Times is the mean Time of the Conjunction or middle of the Eclipse.

2. With Number A, thus collected take out the first Equation of the Conjunction; as also the Equation of Number B, is always to be added to Number B before found.

3. With Number B so Equated, take out the second Equation of the Conjunctions; and in the last Table, the third Equation, as also the Semiduration of the Eclipse answering to Number A.

4. To the mean Time of the middle of the Eclipse, add all those three Equations; the Sum shall be the true Equated Time of the middle of the Eclipse sought.

5. If Number B Equated be less than 500, subtract the Semiduration, and you will have the Time of the Immersion; or if it be more than 500, adding the same, will give the Time of the Emersion. (See the 28th Page of my *System of the Planets Demonstrated*.

N. B.

N. B. The Times thus found are equal Time, which must reduced to the apparent, as has been taught in the 2d *Pre-pt.* And in Leap-year after *February* you must subtract one ay from the Day of the Month.

Example. Let it be required to find the Emersion of *Ju-ter*'s first Satellite *January* 20, 1728?

OPERATION.

	D.	*H.*	*M.*	*S.*	*Nu.* A.	*Nu.* B.	
1728	0	21	20	8	630	636	
anuary	19	11	14	36	4	51	
Mean Conj.	20	8	34	44	634	687	
Equated 1		1	9	19		4	Eqat. B.
Equated 2			5	6			
Equated 3				38		691	B. Equat.
Middle	20	9	49	47			
Semid. add		1	4	44			
January	20	10	54	31	Emersion Equal Time.		
Equat. sub.			14	4			
Appar. Time	20	10	40	27			

Example 2. Let it be required to find the Immersion of *Jupiter*'s first Satellite *August* 26, 1728?

OPERATION.

	D.	*H.*	*M.*	*S.*			
1728	0	21	20	8	630	636	
Aug. Biss.	25	22	20	54	55	598	
	26	19	41	2	685	229	
Equation 1		1	15	53		1	Equat. B.
Equation 2			8	33			
Equation 3			1	1		230	
Middle	26	21	6	36			

	D.	H.	M.	S.	
Semid. sub.		1	6	2	
August	26	20	0	34	Equal time of the Immersion.
Equat. add			2	18	
Apparent	26	20	2	52	Immersion.

At which Time the true Place of the Sun is ♍ $14^{\circ}\ 47'\ 58''$, the mean Anomaly 2 S. $8^{\circ}\ 1'\ 39''$ which gives the Equation of Time $2'\ 18''$ to be added as above; therefore the apparent Time is at $2'\ 52''$ past 8 o'Clock in the Morning of the 27th Day.

Example 3. Let the Time of the Emersion of this Satellite be required *December* 25, 1728?

OPERATION.

	D.	H.	M.	S.		A	B	
1728	0	21	20	8	=	630	636	
Decem. Biss.	24	6	45	40	=	83	900	
December	25	4	5	48	=	713	536	
	1	1	17	40			0	Equ. B.
Equation	2		0	13				
	3		1	25				
Equat.	25	5	25	6	Middle			
Semidur. add		1	6	51				
December	25	6	31	17				
Eq. time sub.			4	14				
Apparent	25	6	27	43				
1 Revol. add	1	18	28	36				
T. of the next	27	0	56	19	Emersion.			

After this manner may you easily compute the Times of the Immersions and Emersions of this Satellite; and if you are fitted with a good Telescope and Pendulum Clock, you may compare your Observations with your Calculations, and I doubt not but you find them agree, as I have often experienced. When these Tables of the first Satellite of *Jupiter* were pub-lish'd

lish'd by Mr *Pound*, there were several Typographical Errors, which I have taken care to correct, by the Directions of the Reverend Author; from whom I receiv'd the Corrections done by his own Hand, which I have apply'd; and now these Tables appear from any Error, I hope, to the Satisfaction of the most Curious in Astronomy.

PRECEPT XXI.

Shewing how to find the Hour of the Night by the Shadow of the Moon upon a Sun-Dial.

First, By *Problem* 47, find the true Time of the Moon's southing: Then observe, if the Shadow of the Moon fall among the Morning-hours upon a Sun-dial, whatever the Shadow wants of 12 o'Clock by the Dial, subtract from the Time of the Moon's southing: But if the Shadow of the Moon fall among the Afternoon-hours, so many as it is past 12 by the Dial, add to the true Time of the Moon's southing; the Sum, or Difference, is the true Hour and Minute of the Night.

Example. Anno 1728, *January* 16, at *London*, the true Time of the Moon's southing was at 13' past 12 at Night; and I observing the Shadow on a Sun-dial to fall upon the 11 o'Clock Hour-line, then what was the Hour of the Night?

OPERATION.

	H.	*M.*
True time of the Moon's Southing	12	13
Shadow short of 12 sub.	1	0
Remains the true Hour of the Night	11	13

Example 2. Admit the Moon is South at 7 H. 30' Afternoon; and observing the Shadow upon the Dial to fall on the Hour of 1 H. 30'; I desire to know the true Hour of the Night?

OPERATION.

	H.	M.
True time of the Moon's Southing	7	30
Shadow past 12 add	1	30
Sum, is the true Hour of the Night	9	0

These Rules being so plain, it is needless to give any more Examples.

PRECEPT XXII.

The Calculation and Demonstration of our Pole-Star, that it was not the Pole at the Creation of the World, &c.

In the 119th *Page* of my *System of the Planets Demonstrated*, I have shewn you in what Signs the fixed Stars increase, and in which their Declinations decrease, and also hinted that the present Polar Star would in Process of Time be to the South of the Zenith of *London* ; I shall in this Place clear up that Point, and make it plainly appear to the meanest Capacity, that the Star of the second Magnitude in the End of the Tail of the *Lesser Bear* was not the Polar Star at the Creation of the World.

First, then, You are to understand that this proceeds from two Causes; the one by the Recession of the Æquinox, which makes all the fixed Stars seem to move *in Consequentiâ* 50'' a Year ; the other, is their moving upon the Poles of the Ecliptic, and therefore always keeping at the same Distance from the Ecliptic; but the Declinations or Distance from the Equinoctial being always altering, (as I have shewn in the fore-cited Book) hence it is, that the fixed Stars do not always keep the same Places in the Heavens, but are found sometimes on this side, sometimes on that, sometimes to the North, at other times to the South of your Zenith: And this may seem a Paradox to the unskilful in Astronomy ; but I can assure you, there is not any one Proposition in *Euclid* more Demonstrable in it self, than is now the Case before us.

I shall illustrate this, in giving the Work of the present Polar Star's nearest approach to the Pole, and also shewing when it will be to the South of the Zenith of *London*.

OPE-

OPERATION.

	S.	D.	M.	S.		D.	M.	S.
1727, Long. of the Pole of	2	24	45	31	Lat.	66	4	11 N.
Sub. its Longitude from	3	0	0	0				
Pole is now short of ♋		5	14	29				

```
                          5   14   29
                         60
                        ----
                        314
Now say,                 60
Year.                  ------
If 50″ : 1 : :         18869 Seconds.
                           1
                       -------
                  5|0)1886|9 (377 19/50 Years.
                           1727 add.
                       -------
                         38 2104 Sum.
                         --
                         36
                         --
                       Rem. 19.
```

	D.	M.	S.	
Latitude of the Pole Star is	66	4	11	North.
Obliquity of the Ecliptic add	23	29	0	
Pole's Declination	89	33	11	North

By the Work above it appears, that 377 Years hence, which will be in the Year of Christ 2104 the Pole Star's Longitude will be in the first Minute of *Cancer*, and then its Declination will be 89° 33′ 11″ North, whose Complement to 90° is 0° 26′ 49″, which is the nearest Approach of the Polar Star to the Pole it self that can possibly be.

As, when the Polar Star's nearest Approach to the Pole is when its Longitude is in the first Minute of *Cancer*; so its greatest Distance from the Pole will be when its Longitude is in the first Minute of *Capricorn*. The next thing therefore to be done, is to find how long time it will be e're its Longitude will be in the first Minute of *Capricorn*, that is, in what space of time it will by its Annual Motion move a Semicircle, or from *Cancer* to *Capricorn*; which is found by this Proportion;

Years

			Years	6
If 50''	:	1	: :	180
				60
				10800
				60
				5|0)64800|0(12960 Years.
				Remains 0

By the Work above, I have proved, that in 12960 Years the North Polar Star (and alfo every fixed Star) will move half round the Heavens, and in that time will alter their Declination 46 *Degrees* 56 *Minutes*, equal to the Diftance of the two Tropics; therefore if you fubtract the Diftance of the two Tropics for the Declination of the Polar Star when in *Cancer*, there will remain the Declination of the Polar Star when in *Capricorn*.

OPERATION.

	D.	M.	S.	
Pole's Declination when in *Cancer* is	89	33	11	North.
Diftance of the two Tropics fub.	46	58	0	
Pole's Declination when in *Capricorn*	42	35	11	North.
Declination of the Zenith of *London*	51	32	0	
Diftance of the Polar Star	8	56	49	to the

South of the Zenith, or Vertex of *London*: Then to find when this will be, if to the Year of Chrift 2104, which is the time the Polar Star will be in *Cancer*, you add 12960 the Years it is in moving from *Cancer* to *Capricorn*, the Sum 15064 is the Year of Chrift that the Polar Star that we now obferve will then be 8° 56′ 49″ to the South of the Zenith of *London*.

And if you would know what Star will be the Polar Star in the Year of Chrift 15064 when our Pole that now is, will be to the South of the Zenith of *London* 8° 56′ 49″; it will be a Star of the third Magnitude in the Calf of the left Leg of *Hercules*, whofe Longitude in the Catalogue you will find ♐

16°

16° 2′, and Latitude 69° 22′ North. And the Star that was the Polar Star at the Creation of the World, was a Star of the second Magnitude in the Tail of *Draco*, which I have also Noted in the Catalogue. For the better clearing up of this Point, and for your own Satisfaction, I shall acquaint you how you may prove, what has been said by the Celestial Globe. Thus, take in your Compasses from any great Circle of the Globe, (as from the Equinoctial or Ecliptic) the Latitude of the present Polar Star 66° 4′ 11″; carry this Extent and set one Foot in the very beginning of *Capricorn*, *viz.* in the Point where the Solstitial Colure, the Ecliptic and Tropic meet, or touch each other, and the other Foot will fall in the same Colure 8° 56′ 49″ short, or South of the Zenith of *London*, which is the Place on the Globe where the Pole will be in the Year of Christ 15064.

'Tis certain that all the fixed Stars, do appear every Day to rise and set, and to move with a Circular Motion from East to West; the Plains also of these Diurnal Circular Revolutions being at right Angles to the Earth's Axis, or parallel to the Equator.

All which is fairly and easily accounted for, by supposing our Earth to revolve round its own Axis in 24 Hours from West to East, (as I have proved in my *System of the Planets Demonstrated*:) But the Eye of the Spectator moving round together with the Earth, that must appear to him immoveable as a Ship doth to those that are in it, till by Observation and Judgment they find it otherwise.

There are above 1000 Stars which appear, or that are Visible to the naked Eye; but the Telescope hath discovered above 20 times as many more; and the larger and better these Glasses are, the more are still discovered. With my 13½ Feet Tube I have seen above 20 in the Constellation *Pleiades* where the naked Eye can see no more than six.

That the fixed Stars by reason of their immense Distance, are to be looked upon as Points (unless so far as their Light is dilated by Refraction) is plain from hence, That when by the Appulses of the Moon to them they are Eclipsed or covered by her Body, their Light doth not, like that of the Planets in the like Case, vanish or disappear gradually, but at once and all together; and when they emerge again out of the Eclipse, they do not become Visible by Degrees, but as it were instanteously, or at least, in the space of one or two Seconds. The Distance therefore of the fixed Stars, seem hardly within the reach of any of our Methods to determine; but from what has been laid down, we may

may draw some Conclusions that will much illustrate the Immensity of it.

1. That the Earth's Annual Orbit is but a Point in comparison of the Distance of the Earth and fixed Stars.

2. That could we advance towards the Stars 99 Parts of the whole Distance, and have only $\frac{1}{100}$ Part remaining, the Stars would seem no bigger to us than they do here; for they would shew no otherwise than they do through a Telescope which magnifies an Hundred-fold.

3. That the least nine Parts in ten, of the space between us and the fixed Stars, can receive no greater Light from the Sun or any of the Stars, than what we have from the Stars in a clear Night.

4. That Light takes up more Time in travelling from the Stars to us, than we in making a *West-India* Voyage; That sound would not arrive to us from thence in 50000 Years, nor a Cannon-Ball in a much longer time; this is easily computed by allowing (according to Sir *Isaac Newton* and Mr *Pound*) 7 Minutes for the Journey of Light from the Sun hither; and that Sound moves about 968 Feet in a second of Time, as they found by the Eclipses of *Jupiter's* Satellites, that is eleven Miles in a Minute of Time.

The Velocity of Light, to the Velocity to the Earth's Annual Motion in its Orbit is,

As 10210 to 1. *Philoso. Trans.* N° 406.

The End of the First Volumn.

Days.	*January* H.	'	*Febr.* H.	'	*March* H.	'	*April* H.	'	*May* H.	'	*June* H.	'
1	6A	25	4A	18	2A	31	0A	39	10M	45	8M	40
2	6	21	4	14	2	27	0	35	10	41	8	36
3	6	17	4	10	2	23	0	31	10	37	8	32
4	6	13	4	6	2	20	0	27	10	33	8	28
5	6	10	4	2	2	16	0	23	10	30	8	24
6	6	6	3	58	2	12	0	20	10	25	8	20
7	6	2	3	54	2	8	0	16	10	22	8	15
8	5	59	3	50	2	4	0	12	10	18	8	11
9	5	55	3	46	2	1	0	9	10	14	8	7
10	5	51	3	43	1	58	0	5	10	10	8	2
11	5	47	3	39	1	55	0	1	10	6	7	58
12	5	43	3	35	1	52	11M	58	10	2	7	54
13	5	39	3	31	1	48	11	54	9	58	7	50
14	5	35	3	27	1	44	11	50	9	54	7	46
15	5	31	3	23	1	40	11	46	9	50	7	42
16	5	27	3	20	1	37	11	43	9	46	7	38
17	5	23	3	16	1	33	11	39	9	42	7	34
18	5	19	3	12	1	30	11	35	9	38	7	30
19	5	15	3	8	1	26	11	31	9	35	7	26
20	5	10	3	5	1	22	11	28	9	29	7	21
21	5	6	3	1	1	18	11	24	9	25	7	17
22	5	2	2	57	1	14	11	20	9	21	7	13
23	4	59	2	53	1	10	11	16	9	17	7	9
24	4	54	2	49	1	7	11	12	9	13	7	5
25	4	50	2	46	1	3	11	8	9	9	7	1
26	4	45	2	42	1	0	11	4	9	5	6	57
27	4	40	2	39	0	56	11	0	9	1	6	53
28	4	36	2	35	0	52	10	56	8	57	6	49
29	4	32			0	49	10	52	8	53	6	45
30	4	28			0	45	10	48	8	49	6	41
31	4	23			0	42			8	45		

Days.	July		August		Septem		October		Novem.		Decem	
	H.	'	H.	'	H	'	H.	'	H.	'	H.	'
1	6M	36	4M	34	2M	40	12A	51	10A	51	8A	43
2	6	32	4	30	2	36	12	47	10	47	8	38
3	6	28	4	26	2	33	12	43	10	43	8	34
4	6	24	4	22	2	29	12	40	10	39	8	30
5	6	20	4	18	2	26	12	36	10	35	8	26
6	6	16	4	14	2	22	12	32	10	30	8	21
7	6	12	4	11	2	18	12	28	10	26	8	17
8	6	8	4	7	2	15	12	25	10	22	8	12
9	6	4	4	3	2	11	12	21	10	18	8	8
10	5	59	4	0	2	8	12	18	10	14	8	3
11	5	55	3	56	2	4	12	14	10	10	7	59
12	5	51	3	52	2	0	12	10	10	6	7	54
13	5	47	3	48	1	57	12	2	10	2	7	50
14	5	43	3	44	1	53	12	6	9	58	7	45
15	5	39	3	40	1	50	11	58	9	54	7	41
16	5	35	3	37	1	46	11	54	9	50	7	36
17	5	31	3	33	1	43	11	50	9	46	7	32
18	5	27	3	30	1	39	11	46	9	42	7	28
19	5	24	3	27	1	35	11	42	9	37	7	23
20	5	20	3	24	1	32	11	39	9	31	7	19
21	5	16	3	20	1	28	11	35	9	27	7	15
22	5	12	3	16	1	24	11	31	9	23	7	11
23	5	8	3	13	1	20	11	27	9	18	7	7
24	5	4	3	9	1	17	11	24	9	14	7	3
25	5	0	3	5	1	13	11	20	9	10	6	58
26	4	56	3	2	1	9	11	15	9	6	6	53
27	4	52	2	58	1	5	11	12	9	2	6	49
28	4	48	2	54	1	1	11	7	8	58	6	45
29	4	44	2	50	12	58	11	3	8	54	6	41
30	4	40	2	47	12	54	10	59	8	49	6	33
31	4	37	2	43			10	55			6	31

Days.	*January*		*Febr.*		*Mrch*		*April*		*May*		*June*	
	H.	'	H.	'	H.	'	H.	'	H.		H.	'
1	10	57	8	50	7	3	5	11	3	17	1	12
2	10	53	8	46	7	0	5	7	3	13	1	8
3	10	47	8	42	6	56	5	4	3	9	1	4
4	10	44	8	38	6	52	5	0	3	5	1	0
5	10	40	8	34	6	48	4	56	3	2	0	56
6	10	36	8	30	6	45	4	52	2	58	0	51
7	10	31	8	26	6	41	4	48	2	54	0	47
8	10	27	8	22	6	37	4	44	2	50	0	43
9	10	23	8	18	6	34	4	40	2	46	0	38
10	10	19	8	15	6	31	4	37	2	42	0	34
11	10	15	8	11	6	27	4	33	2	38	0	30
12	10	11	8	7	6	23	4	30	2	34	0	26
13	10	6	8	3	6	20	4	26	2	30	0	22
14	10	2	8	0	6	16	4	22	2	26	0	18
15	9	58	7	56	6	12	4	18	2	22	0	14
16	9	54	7	52	6	9	4	15	2	18	0	10
17	9	49	7	48	6	5	4	11	2	14	0	6
18	9	45	7	44	6	2	4	7	2	10	0	1
19	9	41	7	40	5	58	4	3	2	6	11	57
20	9	37	7	37	5	54	4	0	2	1	11	53
21	9	33	7	33	5	50	3	56	1	57	11	49
22	9	28	7	30	5	46	3	52	1	53	11	44
23	9	24	7	26	5	43	3	48	1	49	11	40
24	9	20	7	22	5	39	3	44	1	45	11	36
25	9	16	7	18	5	35	3	40	1	40	11	32
26	9	12	7	14	5	31	3	36	1	36	11	28
27	9	8	7	10	5	38	3	32	1	32	11	24
28	9	4	7	7	5	24	3	28	1	28	11	20
29	9	9			5	21	3	24	1	24	11	16
30	8	57			5	18	3	20	1	20	11	12
31	8	53			5	14			1	16		

Days.	*July*		*August*		*Septem.*		*Octob.*		*Novem.*		*Decem.*	
	H.	'	H.	'	H.	'	H.	'	H.	'	H.	'
1	11 M	8	9 M	6	7 M	12	5 M	23	3 M	23	1 M	15
2	11	4	9	2	7	8	5	19	3	18	1	11
3	11	0	8	58	7	4	5	15	3	14	1	7
4	10	56	8	54	7	0	5	12	3	10	1	2
5	10	52	8	50	6	57	5	8	3	6	0	58
6	10	48	8	46	6	53	5	4	3	2	0	54
7	10	44	8	43	6	50	5	0	2	58	0	50
8	10	40	8	39	6	46	4	57	2	54	0	45
9	10	36	8	35	6	43	4	53	2	50	0	40
10	10	31	8	32	6	40	4	50	2	46	0	35
11	10	27	8	28	6	36	4	46	2	42	0	31
12	10	23	8	24	6	33	4	42	2	38	0	27
13	10	19	8	20	6	30	4	39	2	34	0	22
14	10	15	8	17	6	26	4	35	2	30	0	18
15	10	11	8	13	6	22	4	31	2	26	0	13
16	10	7	8	10	6	19	4	27	2	22	0	9
17	10	3	8	6	6	15	4	24	2	18	0	4
18	10	0	8	2	6	12	4	20	2	13	0 A	0
19	9	56	7	59	6	8	4	16	2	8	11	56
20	9	52	7	56	6	4	4	11	2	3	11	51
21	9	48	7	52	6	0	4	7	1	59	11	47
22	9	44	7	48	5	57	4	3	1	55	11	42
23	9	40	7	44	5	53	3	59	1	50	11	38
24	9	36	7	41	5	50	3	55	1	46	11	34
25	9	32	7	37	5	46	3	51	1	42	11	29
26	9	28	7	33	5	42	3	48	1	37	11	25
27	9	25	7	30	5	38	3	43	1	33	11	21
28	9	21	7	26	5	34	3	39	1	29	11	16
29	9	17	7	23	5	30	3	34	1	25	11	12
30	9	13	7	20	5	26	3	30	1	20	11	8
31	9	9	7	16			3	26			11	3

Days.	*Janua.* H.	′	*Febr.* H.	′	*March* H.	′	*April.* H.	′	*May* H.	′	*June* H.	′
1	3M	29	1M	22	11	35	9A	43	7A	49	5A	44
2	3	25	1	18	11	31	9	39	7	45	5	40
3	3	20	1	14	11	27	9	35	7	41	5	36
4	3	16	1	10	11	23	9	31	7	37	5	32
5	3	12	1	6	11	20	9	28	7	33	5	28
6	3	8	1	2	11	16	9	24	7	30	5	24
7	3	4	12A	58	11	13	9	20	7	26	5	20
8	3	0	12	54	11	19	9	16	7	22	5	16
9	2	55	12	50	11	6	9	12	7	18	5	10
10	2	51	12	47	11	3	9	9	7	14	5	6
11	2	47	12	43	10	59	9	5	7	10	5	2
12	2	43	12	39	10	55	9	1	7	6	4	58
13	2	39	12	35	10	51	8	57	7	2	4	54
14	2	35	12	31	10	47	8	53	6	58	4	50
15	2	30	12	27	10	43	8	50	6	54	4	46
16	2	26	12	23	10	40	8	46	6	50	4	42
17	2	22	12	20	10	36	8	43	6	46	4	38
18	2	18	12	16	10	33	8	39	6	42	4	34
19	2	14	12	12	10	29	8	36	6	38	4	30
20	2	9	12	9	10	26	8	32	6	33	4	25
21	2	5	12	5	10	22	8	28	6	29	4	21
22	2	1	12	1	10	18	8	24	6	25	4	17
23	1	57	11	57	10	14	8	20	6	21	4	13
24	1	53	11	53	10	10	8	16	6	17	4	9
25	1	49	11	50	10	7	8	12	6	13	4	5
26	1	45	11	46	10	3	8	8	6	9	4	1
27	1	41	11	42	10	0	8	4	6	4	3	57
28	1	37	11	39	9	59	8	0	5	0	3	53
29	1	33			9	52	7	56	5	56	3	49
30	1	30			9	49	7	52	5	52	3	45
31	1	26			9	46				48		

Days.	*July* H.	′	*August* H.	′	*Septem.* H.	′	*October* H.	′	*Novemb.* H.	′	*Decem.* H.	′
1	3 A	40	1 A	38	11 M	44	9 M	55	7 M	55	5 M	47
2	3	36	1	34	11	40	9	51	7	51	5	43
3	3	32	1	30	11	36	9	47	7	47	5	39
4	3	28	1	26	11	32	9	44	7	43	5	35
5	3	24	1	22	11	29	9	40	7	38	5	30
6	3	20	1	18	11	25	9	36	7	34	5	26
7	3	15	1	14	11	22	9	33	7	30	5	22
8	3	11	1	10	11	19	9	29	7	26	5	17
9	3	7	1	7	11	15	9	25	7	22	5	12
10	3	3	1	4	11	12	9	22	7	18	5	7
11	2	59	1	0	11	8	9	18	7	14	5	2
12	2	55	0	56	11	4	9	14	7	10	4	58
13	2	51	0	52	11	9	9	10	7	6	4	54
14	2	47	0	48	10	56	9	6	7	1	4	50
15	2	43	0	44	10	53	8	2	6	58	4	45
16	2	40	0	40	10	49	8	58	6	54	4	40
17	2	36	0	37	10	46	8	54	6	50	4	36
18	2	32	0	34	10	43	8	50	6	46	4	32
19	2	28	0	31	10	40	8	46	6	41	4	28
20	2	24	0	28	10	36	8	43	6	35	4	23
21	2	20	0	24	10	32	8	39	6	31	4	19
22	2	16	0	20	10	29	8	35	6	27	4	15
23	2	12	0	16	10	25	8	31	6	23	4	10
24	2	8	0	12	10	22	8	27	6	18	4	6
25	2	4	0	9	10	18	8	23	6	14	4	1
26	2	0	0	5	10	14	8	19	6	10	3	57
27	1	56	0	1	10	10	8	15	6	6	3	53
28	1	53	11 M	57	10	6	8	11	6	2	3	48
29	1	49	11	53	10	2	8	7	6	58	3	44
30	1	45	11	50	9	58	7	4	5	53	3	40
31	1	41	11	47			7	59			3	35

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